PEDIATRIC

NEONATOLOGY

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Introduction

Neonatal period
The first 28 days of life

Perinatal period
The period from 28th week of gestation till D_{28} of life

Abortion
Termination of pregnancy before **viability** of the fetus
Viability is a reasonable chance of survival (20-28 weeks or ≥ 500 g)

Still Birth
Fetus born dead after viability

Duration of Pregnancy
280 days = 40 weeks (starting from the 1st day of the last menstrual period)
266 from the day of fertilization
- ☒ **1st trimester:** 1st 12 weeks
- ☒ **2nd trimester:** 13-28 weeks
- ☒ **3rd trimester:** 28-40 weeks

Infants are classified as:
- Preterm: delivery before 37 weeks
- Term: 37-42 weeks
- Post-term: ≥ 42 weeks

Placenta
- Shape: Discoid
- Diameter: 15-20 cm
- Weight: 500 gm
- Site: Upper uterine segment

Antepartum Hemorrhage
- ☒ **Placenta previa:** Placental implantation over the lower uterine segment
- ☒ **Accidental hemorrhage:** Premature separation of a normally implanted placenta

Presentation
The presenting part is the lowermost part of the fetus
- ☒ **Cephalic**
- ☒ **Breech**
- ☒ **Shoulder**

The placenta is normally attached to the upper uterine segment

Position
The direction of the back of the fetus in relation to the mother

Lie
The relation between the long axis of the fetus & that of the mother
- ☒ **Longitudinal** (cephalic & breech)
- ☒ **Transverse** (shoulder)

Precipitate Labor
Less than 3 hours

Prolonged Labor
More than 24 hours

Fetal membranes
1. **Chorion:** The outer membrane, in contact with the uterine wall, ends at the placental margins
2. **Amnion:** The inner membrane, covers the fetal surface of the placenta & umbilical cord

Premature Rupture of membranes (PROM)
Rupture of membranes before the onset of labor (Premature & Antepartum)

Overview of Mortality & Morbidity

Definition

- **Perinatal mortality:** Deaths in the perinatal period
- **Neonatal mortality:** Deaths in the neonatal period
- **Infant mortality:** Deaths occurring from birth- 12 months
- **Postneonatal mortality:** Deaths occurring after the neonatal period & till 1 year of age

Mortality

Causes

Fetal	Preterm	Full term
Placental Insufficiency	Severe immaturity, RDS, BPD	Congenital anomalies
Placental separation	IVH	Infection
Umbilical cord accidents	NEC	MAS
Congenital anomalies	Congenital anomalies	PPHN
Congenital infections	Infection	Trauma

Morbidity

Causes

System	Immediate	Late
CNS	Hypoxic Ischemic Encephalopathy (HIE) Intracranial hemorrhage (ICH) Seizures Kernicterus Hypotonia	Mental retardation CP (Spastic, choreoathetotic), seizures Learning disabilities Speech & language disorders Microcephaly Hydrocephalus
Hearing & Vision	Retinopathy of prematurity	Hearing & visual impairment Myopia & squint
Respiratory system	Respiratory Failure (RDS) Apnea Pneumthorax	BPD Cor pulmonale Subglottic stenosis Iatrogenic cleft palate
Cardiac	Heart failure PDA (70% if < 1.000 gm)	HTN (Dexamethasone,renal a. stenosis)
GIT	NEC Weak suckling & swallowing	Short bowel syndrome Malabsorption, Malnutrition GERD
Hepatic	Neonatal cholestasis *(sepsis, TPN...)* Indirect hyperbilirubinemia	Cirrhosis Liver cell failure
Renal	ARF *(causes)* ↓↓ Na, ↑↑ Na, ↑↑ K, RTA, glucosurria	Nephrocalcinosis HTN *(renal artery stenosis)*
Nutritional	Nutritional deficiencies	Ostepenia, fracture & deformities FTT
Social	Social stress	Child abuse Divorce
Skin	Injury	Scars (PDA, chest tube), Hernia
Infection	Infection	Recurrent infection (pneumonia)
Hematologic	Anemia, Bleeding (↓↓ PLT, DIC, ↓↓ vit.K)	Bleeding sequelae
Metabolic	↓↓ Ca, ↓↓ Glucose Hypo& Hyperthermia	

High Risk Pregnancies

Definition

Pregnancies associated with ↑↑ risk of

- ☒ Abortion, IUFD or IUGR
- ☒ Prematurity, congenital anomalies or neonatal disease

Identification of high risk pregn icies important to **avoid** perinatal mor dity & mortality

Incidence

- Constitute 10-20% of all pregnancies
- Associated with 50% of all perinatal morbidity & mortality

Factors associated with high risk pregnancy

Economic	Reproductive
Poverty Unemployment Uninsured	Previous infant with CP, MR or cong. anomalies Previous infertility Conception by reproductive technology Multiple pregnancies Pre-eclampsia or eclampsia Antepartum hemorrhage (2) Abnormal presentation (breech) or lie (transverse) Abnormal fetal growth AF: Oligohydramnios or polyhydramnios ↑↑ or ↓↓ MSAFP Premature or Post-term labor PROM Prolonged labor CS or instrumental deliveries
Biologic	
Short stature Malnutrition Poor weight gain during pregnancy Obesity	
Demographic social factors	**Maternal Diseases & Drugs**
Age < 20 or > 35 years Unmarried Physical stress Low educational status Cigarette, alcohol or drug abuse	

High Risk Infants

Definition

Infants need to be under close observation (usually for few days)

Identification of high risk infa ts is important to **avoid** perinatal morbidit & mortality

Incidence

- Constitute 9% of all pregnancies
- Associated with ↑↑ neonatal morbidity & mortality

Etiology *(+ high-risk pregnancies)*

Previous Pregnancy	Labor & Delivery
Abortion, IUFD or IUGR Prematurity, congenital anomalies or neonatal disease	Prolonged or Precipitate labor Premature baby or post-term baby PROM CS or instrumental deliveries Fetal distress Meconium stained amniotic fluid Low Apgar score
Present Pregnancy	**Neonate**
Conception by reproductive technology Multiple pregnancies Pre-eclampsia or eclampsia Antepartum hemorrhage (2) Abnormal presentation (breech) or lie Abnormal fetal growth Oligohydramnios or polyhydramnios	Premature or post-term SGA or LGA Pallor, jaundice, cyanosis, tachypnea Congenital anomalies

Amniotic Fluid

Production

- ☒ 1st half of pregnancy: Secretion by the amniotic epithelium
  Transudation from maternal & fetal circulation
- ☒ 2nd half of pregnancy: Fetal urine

Volume

500-2000 mL

Function

1. Protection
2. Development of fetal musculoskeletal system "Movement"
3. Growth factors for lung maturation "inhaled by the fetus"

Abnormalities

	Polyhydramnios	Oligohydramnios
Definition	Amniotic fluid > 2000 ml	Amniotic fluid < 500 ml
Etiology	1. Idiopathic* (60%) 2. Fetal polyuria (RTA, DI, Bartter) 3. Anencephaly, hydrocephalus & meningocele "Leakage" 4. Esophageal atresia (TOF) 5. Intestinal atresia 6. N/M disorders • Nerves: SMA type 1 (W.H.) • Muscles: Congenital myopathy Myotonic dystrophy 7. DM 8. Twin to twin transfusion syndrome 9. Achondroplasia 10. Hydrops fetalis (Fetal heart failure, anemia, chromosomal…)	1. Idiopathic 2. Amniotic fluid leak 3. Amnion nodosum *(granules on amnion)* 4. Renal oliguria (agenesis, ARPKD) 5. Obst. uropathy (PUV, urethral atresia) 6. Twin to twin transfusion syndrome 7. Drugs • ACE inhibitors • Indomethacin 8. Pulmonary hypoplasia **Potter syndrome:** ▪ Renal agenesis ▪ Oligohydramnios ▪ Potter facies: flat nose, micrognathia, low-set ears, limb-positioning defects

Examination of Placenta, Cord & Membranes

A) Placenta

- Placental pallor: Fetal blood loss
- Placental opacity: infection
- Placental edema: Hydrops fetalis *(mention causes)*

Umbilical cord
Length = 50 cm
Diameter = 1-2 cm

B) Membranes

- Amnion nodosum
- Oligohydramnios

C) Cord

- Short cord: may be associated with fetal hypotonia, & chromosomal abnormalities
- Long cord: ↑↑ risk of true knots
- Single umbilical artery: Chromosomal abnormalities (trisomy 18), urinary anomalies
- Meconium staining: Fetal asphyxia
- Whitish nodules on the cord: Candida infection

The Fetus

Fetal life begins with completion of organogenesis (≈ 12 weeks)

A) Assessment of Fetal Growth

Method: U/S measurement of

- Biparietal diameter,
- Femur length
- Abdominal cross-sectional area
- Estimated fetal weight

Results:

- ☒ Appropriate for gestational age (AGA)
- ☒ Large for gestational age (LGA)
- ☒ Small for gestational age (SGA) = IUGR →
  - Symmetric *(continuous)* [Congenital infection, chromosomal]
  - Asymmetric *(Late flattening pattern)* [Placental insufficiency]

B) Assessment of Fetal Well being

I Antepartum assessment (= Diagnosis of placental insufficiency)

1. Daily fetal movement count

Count of 10: If 10 movements are not counted in 10 hours, the fetus may be at risk

2. Non-stress test

Idea: Normally, fetal movements are accompanied by fetal HR acceleration

Technique: Monitoring of FHR in response to fetal movements (Duration = 20 min)

Results:

- ☒ Reactive: 3 criteria;
  - **a.** FHR = 120-160/min
  - **b.** Beat-to-beat variability (3-6/min)
  - **c.** 2 accelerations of ≥ 15 beats/min lasting for ≥ 15 seconds
- ☒ Non-reactive → further investigation

3. Contraction stress test

Idea: Normally, during uterine contractions there is deceleration of fetal HR.
The onset & the end of deceleration coincide with the onset & end of contraction

Technique: IV infusion of oxytocin to produce uterine contraction

Results:

- ☒ Early deceleration "Normal" [Mirror-image]
- ☒ Late deceleration "Placental insufficiency": Deceleration is prolonged, so the end of deceleration is delayed after the end of contraction

Contraindications: Incompetent cervix, PROM, previous uterine scar

4. Biophysical profile (BPP)

	Score = 2	Score = 0
Non-stress test	Reactive	Non-reactive
Fetal movements	≥ 3 body/limb movements in 30 min	
Fetal respiratory movements	≥ 1 breath movements in 30 min (lasting ≥ 30 seconds)	
Fetal Tone	≥ 1 active extension with return to flexion or hand opening & closure	
Amniotic fluid Vol.*	≥ 1 AF pocket ≥ 2 cm x 2 cm	

Score 8-10
Reassuring
1 week

Score 6
Equivocal
48 hours

Score ≤ 4
Ominous
Delivery

5. Doppler: Study of blood flow velocity in the umbilical artery
↓↓ Blood flow indicates placental insufficiency

II Intrapartum assessment

1. Continuous FHR monitoring (FHR patterns)

FHR & uterine contractions are simultaneously recorded

Normal FHR ⟹

Abnormal FHR

Normal FHR:
1. Rate 120-160/min
2. Beat-to-beat variability (3-6)
3. ↑↑ with fetal movement
4. ↓↓ with uterine contractions (Early deceleration)

a. Tachycardia (FHR > 160)
- Early hypoxia
- Maternal fever, drugs (β-sympathomimetics) & thyrotoxicosis
- Fetal anemia, arrhythmia

b. Bradycardia (FHR < 120)
- Hypoxia
- Maternal drugs (β-blockers), SLE
- Fetal arrhythmia (heart block)

c. Loss of beat-to-beat variability
- Hypoxia
- Maternal drugs (narcotics, $MgSO_4$)
- Fetal immaturity

d. Late deceleration ⟶ Fetal hypoxia

e. Variable deceleration ⟶ Cord compression Fetal hypoxia

2. Fetal scalp blood sampling

Using vaginal speculum, lancet & capillary tube

a. pH ≥ 7.25 ⟶ Normal
b. pH 7.2-7.25 ⟶ Borderline
c. pH ≤ 7.2 ⟶ Fetal hypoxia *(anaerobic metabolism)*

3. Fetal scalp pulse oximetry

4. Passage of meconium in cephalic presentation ⟶ Fetal hypoxia

Causes of Intrauterine Asphyxia

A) Maternal causes
- Cardiac: Heart failure, Shock
- Respiratory failure
- Severe anemia
- Hypotension (blood loss)
- Eclampsia (convulsions)

B) Placenta (Placental insufficiency) ⟹

C) Cord
- Compression (fetal head, forceps)
- Prolapse
- Ruptured vasa previa

D) Compression of fetal head
- Pelvis (Cephalo-pelvic disproportion)
- Forceps
- ICH, depressed fracture

Causes of Placental Insufficiency

☒ **Acute:** Placental separation (Placenta previa & accidental Hge)

☒ **Chronic:**
- Pregnancy-induced HTN (Pre-eclampsia)
- Chronic HTN
- Advanced DM
- Placental infarction
- Placental aging (Post-term)
- Sickle cell anemia
- Smoking
- Drugs: cocaine
- Idiopathic

Diagnosis: *see before*

C/P: IUGR, IUFD

Diagnosis: *see before*

Rx: Immediate delivery

Positioning (on the Lt Side) + oxygen supplementation

Surfactant/Albumin ratio in AF

C) Assessment of Fetal Functional Maturity

a. Renal functional maturation: **Amniotic fluid creatinine level**
Early in pregnancy, AF creatinine is equal to maternal serum creatinine
By 37 wks, AF creatinine: Maternal serum creatinine is ≥ 3

b. Lung functional maturation: **Lecithin/ Sphingomyelin ratio** (and S/A ratio)
In the 3rd trimester, L/S = 1
By 35 wks, L/S = 2 (Indicates lung maturity with ↓↓ risk of development of RDS)

D) Effects of Maternal Diseases on the Fetus

System	Maternal Disease	Effect
CVS	CHD, RHD, HF	IUGR (Placental insufficiency)
	HTN	IUGR (Placental insufficiency)
	PIH	IUGR (Placental insufficiency)
CNS	Myasthenia gravis	Transient neonatal myasthenia (Transplacental Ab)
	Myotonic dystrophy	Myotonic dystrophy (Genetic, AD, anticipation)
Hematologic	ITP, SLE	Neonatal thrombocytopenia (Transplacental Ab)
	NATP	Neonatal thrombocytopenia (Transplacental Ab)
	Sickle cell anemia	IUGR (Placental insufficiency)
Collagen	SLE (or Sjogren)	Fetal & neonatal heart block (Transplacental Ab)
Metabolic	Phenyketonuria (PKU)	Microcephaly, MR (↑↑ Maternal phenyalanine)
Endocrine	DM	LGA (Fetal hyperglycemia & hyperinsulinemia) Neonatal hypoglycemia IUGR (Placental insufficiency & Vascular disease)
	Graves disease	Transient neonatal thyrotoxicosis (Transplacental Ab)
	Endemic goiter	Hypothyroidism (iodine deficiency)
	Hyperparathyroidism	Neonatal hypocalcemia (Fetal hypercalcemia)
	Hypoparathyroidism	Neonatal hypercalcemia (Fetal hypocalcemia)
Nutritional	Obesity	LGA & Neonatal hypoglycemia
	Malnutrition	IUGR (↓↓ fetal nutrients)

Teratogens

Definition

Teratogen is any environmental agent (drug, substance or exposure) that interferes with normal embryonic development (structure, growth or function)

Examples:
- Drugs
- Infection
- Maternal diseases DM & PKU
- Radiation (ionizing & non-ionizing)

Mechanism of teratogens:
1. DNA damage
2. Cell death
3. Vascular insult
4. Delayed differentiation

Effect The effect depends on:

☒ Nature of the teratogen *(The mechanism is usually unknown)*
Warfarin is teratogenic on fetal cartilages [# carboxylation of glutamic acid]

☒ Time of exposure (fetal age)
a. Weeks 1-3 (embryonic stage): All or none fashion; either killing or no effect
b. Weeks 3-10 (organogenesis): organs are most susceptible to damage
c. Weeks 10-40 (fetal growth& maturation): ↓↓ risk but may interfere with function

☒ Genetic predisposition: teratogens are not universal "Pharmacogenetics"

E) Effects of Maternal Medications on the Fetus

1. Drugs affecting the fetus & newborn

	Drug	Effect
1	**Alcohol**	IUGR
2	**Amphetamine**	IUGR
3	**Caffeine**	IUGR, Abortion
4	**Cigarette smoking**	IUGR
5	**Cocaine**	IUGR, microcephaly
6	**ACE inhibitors** (Captopril)	Renal impairment, Oligohydramnios
7	**Indomethacin**	Renal impairment, Oligohydramnios
8	**Mercury**	MR, microcephaly
9	**Methyltestosterone**	Masculinization of the ♀ fetus
10	**Progesterone**	Masculinization of the ♀ fetus
11	**Propranolol**	Fetal bradycardia
12	**Sympathomimetics** (tocolytics)	Fetal tachycardia
13	**Propylthiouracil**	Goiter
14	**Phenytoin**	Congenital anomalies, bleeding (anti-Vit. K)
15	**Valproate**	Congenital anomalies, spina bifida
16	**Streptomycin**	Deafness
17	**Tetracycline**	Enamel hypoplasia, pigmentation of teeth
18	**Thalidomide**	Phocomelia
19	**Vitamin D**	Supravalvular aortic stenosis
20	**Warfarin**	Bleeding, cartilage anomalies

2. Drugs affecting the newborn

	Drug	Effect
1	**Anesthesia**	CNS depression
2	**$MgSO_4$**	Respiratory depression
3	**ACE inhibitors** (Captopril)	Renal impairment, oliguria
4	**Indomethacin**	Renal impairment, oliguria, bleeding, perforation
5	**Aspirin**	Bleeding, perforation
6	**Oxytocin**	Hyperbilirubinemia, Hyponatremia
7	**Vitamin K**	Hyperbilirubinemia
8	**Sulfonamide**	Hyperbilirubinemia, hemolysis in G6PD deficiency
9	**Primaquine** (anti-malarial)	Hemolysis in G-6-PD deficiency
10	**Nitrofurantoin**	Hemolysis in G-6-PD deficiency
11	**Iodide** (Amiodarone)	Neonatal goiter
12	**Lead**	↓↓ intellectual functions
13	**Propranolol**	Neonatal bradycardia & hypoglycemia
14	**Sympathomimetics** (tocolytics)	Neonatal tachycardia
15	**Sulfonylurea**	Hypoglycemia

F) Fetal Diagnosis & Therapy

I Antenatal Diagnosis

1. Maternal serum α-fetoprotein (MSAFP)

- ☒ ↓↓ MSAFP: Down syndrome & other trisomies
- ☒ ↑↑ MSAFP: Neural tube defects (anencephaly, encephalocele, spina bifida)
  Hydrocephalus
  GIT: TOF, Intestinal atresia
  Renal: Congenital nephrosis, Obstructive uropathy
  Twins, IUFD

2. Fetal US

- ☒ Assessment of fetal growth & gestational age
- ☒ Assessment of fetal well-being (e.g., BPP, Doppler study of the umbilical artery…)
- ☒ Nuchal Translucency thickening (NT): thickening of the fat pad at the back of the neck
- ☒ Dilated cerebral ventricular system (hydrocephalus)
- ☒ Dilated renal pelvicalyceal system [large UB in PUV]
- ☒ Absent stomach (TOF), Double-bubble (duodenal atresia), Distended loops (IO)
- ☒ Fetal echocardiography
- ☒ Obstetric applications:
  - Diagnosis of pregnancy & multiple pregnancies
  - Estimation of gestational age
  - Localization of the placenta, AF volume
  - Diagnosis of position, presentation & lie

3. Amniocetesis & Chorionic Villus Sample (CVS)

	Amniocentesis	Chorionic villus sample
Timing	2nd Trimester (14-16 weeks of gestation)	1st Trimester (9-12 weeks of gestation)
Anesthesia	LA or GA	LA or GA
Technique	Transabdominal or transvaginal sample of amniotic fluid (US guided)	Transvaginal transcervical biopsy of chorionic villi (US guided)
Obtained Cells	**1. Fetal sexing** (XL diseases e.g., hemophilia, Duchenne …) **2. Karyotyping** (chromosomal abnormalities e.g., Down, trisomies…) **3. DNA analysis** (Thalassemia, Sickle cell disease, cystic fibrosis…) **4. Enzyme assay** (Galactosemia, GSD, Gaucher, Niemann-Pick, MPS, GM_1, GM_2)	
Liquid phase (in amniocetesis)	1. α-fetoprotein (causes as MSAFP) 2. Bilirubin (Erythroblastosis fetalis) 3. Lung maturity (L/S ratio…) 4. Renal maturity (creatinine) 5. CAH (↑↑ Ketosteroids) 6. Congenital hypothyroidism (↓↓ T_4)	??
Complications	▪ Abortion ▪ Fetal injury ▪ Hemorrhage ▪ Rh sensitization ▪ Infection (amnionitis)	▪ Abortion (2% higher) ▪ Amnion puncture ▪ Hemorrhage ▪ Rh sensitization ▪ Infection
Pros & Cons	▪ Less risk of abortion ▪ Technically easier ▪ ↓↓ yield of cells (cells must be cultured)	▪ ↑↑ yield of cells (rapid diagnosis) ▪ Early in pregnancy (when termination is less risky& less emotionally traumatic)

4. Fetoscopy& Fetal Tissue Sampling

Transabdominal introduction of fetoscope under LA (US guided), 2nd trimester

a. Direct visualization (structural anomalies e.g., phocomelia, neural tube defects…)

b. Cordocentesis (Fetal blood sampling)

- Hemoglobinopathies: Sickle cell anemia
- Coagulation disorders (Hemophilia)
- Neonatal alloimmune thrombocytopenia
- Fetal infection (Toxoplasmosis)
- Immunodeficiency
- Karyotyping, DNA analysis & enzyme assay

c. Fetal liver biopsy (PKU & OTC deficiency)

d. Fetal skin biopsy (epidermolysis bullosa)

OTC = Ornithine transcarbamoylase
Most common type of urea cycle defects
XL-R الوحيد

5. Pre-implantation genetic diagnosis (PGD)

II Fetal Therapy

System	Fetal Disease	Treatment
CVS	SVT	Maternal digitalis, amiodarone
	Heart block	Pacemaker
CNS	Hydrocephalus	Shunt *(Ex-utero intrapartum)*
	Neural tube defects	Folic acid supplementation (Prevention)
Hematologic	Anemia with Hydrops	Packed RBC (Umbilical vein)
	Thalassemia	Stem cell transplantation
	Maternal ITP & SLE	Maternal IVIG & steroids
	NATP	Maternal IVIG & Platelet transfusion (Umbilical vein)
	Chronic granulomatous disease (CGD)	Stem cell transplantation
	SCID	Stem cell transplantation
Respiratory	Lung immaturity	Maternal dexamethasone
	Hypoxia (& IUGR)	Maternal oxygen & position
Metabolic	Maternal PKU	Maternal phenyalanine restriction
	Fetal Galactosemia	Maternal Lactose free diet
Endocrine	DM	Maternal glycemic control
	Graves disease	Maternal Proplythiouracil
	Endemic goiter	Fetal Hypothyroidism (Intra-amniotic thyroxine)
	CAH	Maternal dexamethasone (When??)
Amniotic fluid	Oligohydramnios	Amnioinfusion
	Polyhydramnios	Amnioreduction
Renal	Obstructive Uropathy	Vesicoamniotic shunt
	Bartter syndrome	Maternal Indomethacin therapy
Infections	GBS	Maternal ampicillin (Prevention)
	CMV	Gancyclovir (Umbilical vein)
	HIV	Zidovudine
	Toxoplasmosis	Spiramycin, pyrimethamin, Sulfadiazine, Folic
	TB	Anti-TB drugs
	Lyme, Syphilis	Penicillin
TTTS		YAG Laser photocoagulation of shared vessels

III Prevention of Fetal & Neonatal Disease

1. Folic acid supplementation ↓↓ risk of neural tube defects (NTDs): 400 µg/day
   - ♀ without previous history of NTDs: 400 µg/day
   - ♀ with previous history of NTDs or +ve family history: 4 mg/day
2. Anti-D for prevention of erythroblastosis fetalis
3. Steroids for prevention of RDS
4. MMR vaccine to all ♀ before the age of 12 yrs (pregnancy should be avoided for 3 m)
5. Tetanus toxoid for prevention of neonatal tetanus
6. Rx of maternal diseases
   - Infections: Syphilis, UTI…
   - Noninfectious: control of DM, PKU, ITP…
7. Fetal transfusion
   - Blood: immune hydrops
   - Platelet: Neonatal alloimmune thrombocytopenic pupura
8. Prevention of prematurity
   - Antenatal care for early diagnosis & Rx of causes of prematurity (PIH, PN, DM…)
   - Avoid stress, heavy work
   - Rest & proper diet
   - Tocolytics (Ritodrine…) & Cerclage operation

G) Assessment of Gestational Age

Importance

a. Proper assessment of fetal growth, fetal well being & fetal functional maturity
b. Proper timing of antenatal diagnostic procedures (amniocentesis & CVS)
c. Proper timing of elective obstetric procedures (elective CS)
d. Identification of premature delivery (? neonatal management)

Methods

a. History: 1st day of the last menstrual period (LMP)
b. Examination: Fundal level
c. U/S
   - 1st trimester: Crown-rump length
   - 2nd trimester: Biparietal diameter & femur length

1. Fetal Growth
2. Fetal well being
3. Fetal functional maturity
4. Maternal Diseases
5. Maternal Medications
6. Fetal Diagnosis, Rx & prevention
7. Gestational Age

NB:

Classification of Teratogens (Teratogenic Drugs)

	Risk	Based on??
Category A	No risk	Human trials
Category B	No risk	Animal trials
Category C	Risk	Animal trials (No adequate human trials)
Category D	Risk (Benefits > Risk)	Human or Animal trials
Category X	Contraindicated (Risk > Benefits)	Human or Animal trials

Prevention of Teratogenesis

- Avoid drugs, infection & radiation
- Control of maternal DM, PKU
- Abortion

Neonatal Examination

Examination in the Delivery Room

1. **Color**
   - ☒ Cyanosis
     - Central: Respiratory, cardiac, CNS or methemoglobinemia
     - Peripheral (acrocyanosis): Hypothermia
     - Differential: ↑↑ Pulmonary vascular resistance
   - ☒ Pallor
     - Anemia
     - Hypoxia
     - Edema
   - ☒ Jaundice (rare in the delivery room)
   - ☒ Meconium staining

2. **Respiration**
   - ☒ RD (Tachypnea, retraction, grunting, cyanosis)
   - ☒ Bradypnea (CNS depression)
   - ☒ Stridor (Partial obstruction at the level of upper airways)
   - ☒ Auscultation (air entry- ? intestinal sounds)

3. **CVS**
   - ☒ Heart (rate & murmurs)
   - ☒ Peripheral pulses

4. **Abdomen**
   - ☒ Scaphoid abdomen (Diaphragmatic hernia)
   - ☒ Organomegaly (Congenital infection & metabolic)
   - ☒ Cord examination (long, short, single umbilical artery)

5. **Genitalia**
   - ☒ Sex of the baby
   - ☒ Atypical genitalia (ambiguous)

6. **Gastric aspiration:** ↑↑ in IO (> 30 cc)

7. **Choanal atresia:** using suction catheter

8. **Imperforate anus:** using the same catheter

9. **Congenital anomalies:** e.g., meningocele…

10. **Apgar score:** assigned at 1, 5 minutes ± 10 & 20 minutes
    It is a practical method for assessment of newborns during the 1st few minutes of life

Abdominal mass in a neonate:
1. **Renal****
   - **ARPKD, ADPKD**
   - **MCDK**
   - **Hydronephrosis**
   - **Renal vein thrombosis**
   - **Wilms tumor**
2. **Adrenal Hge**
3. **Neuroblastoma& hepatoblastoma**
4. **Hydrometrocolpos**
5. **Cysts**
   - **Mesenteric**
   - **Choledochal**
   - **Ovarian**
   - **Pancreatic**
6. **HSM**

Sign	0	1	2
Heart rate*	Absent	< 100	>100
Respiration*	Absent	Slow, irregular	Good, crying
Tone	Limp	Some flexion	Active movements
Reflex to suction	No response	Grimace	Cough, sneeze, crying
Color*	Blue or pale	Pink body, blue extremities	Pink

Apgar at 1 minute is an index of intapartum asphyxia & need for resuscitation
Apgar at 5 minutes is used to assess the efficiency of resuscitation
Apgar at 15 & 20 minutes is used to determine the prognosis
Monitoring during resuscitation is used by assessing respiration, HR & color (every 15-30 sec)

Examination in the Nursery

A) Vital Signs

Estimated heat loss in neon: es is 4 times that of an adult

1. **Temperature** (axillary)
   Avoid hypothermia during examination (radiant warmer)

2. **Respiratory rate**
   - ☒ Rate = 30-60/minute
   - ☒ Rhythm: regular (periodic breathing is normal during sleep)
   - ☒ Signs of RD (Tachypnea, retraction, grunting, cyanosis)
   - ☒ Bradypnea (CNS depression)
   - ☒ Stridor (Partial obstruction at the level of upper airways)
   - ☒ Auscultation (air entry-bronchovesicular- ? intestinal sounds)

HR & RR should be counted over 1 minute

3. **Heart rate**
   - ☒ Rate = 120-160/minute [Range = 90 (sleep)- 180 (crying)]
   - ☒ Peripheral pulses

4. **Blood pressure**
   - ☒ Normal ≈ 80/40 (mean BP = 40-50 mmHg)
   - ☒ Method: auscultatory or automated (DINAMAP)
   - ☒ In UL & LL (Coarctation)

Device for Indirect Noninvasive Autom ed Mean Arterial Pressure

B) Anthropometric Measurements

1. **Length** ≈ 50 cm
2. **Wight** ≈ 2.500-3.999 Kg
3. **Skull circumference** ≈ 35 cm

} *Growth curves*

C) Systemic Examination

1. Skull

- ☒ Molding (overlapping sutures)
- ☒ Cephalhematoma
- ☒ Caput succedenum
- ☒ Depressed fracture
- ☒ Large AF (hydrocephalus, hypothyroidism)
- ☒ Open Post. Fontanel
- ☒ Mcrocephaly
- ☒ Microcephaly

White pupil reflex:
1. Cataract
2. Glaucoma
3. Retinoblastoma

2. Eyes

- ☒ Lid swelling: infection, irritation
- ☒ Upward slanting: Down
- ☒ Cornea: opacities
- ☒ Conjunctiva: Subconjuctival Hge
- ☒ Lens: Cataract
- ☒ Glucoma (blue sclera)
- ☒ Iris: Coloboma (Key-shaped pupil)
- ☒ Fundus: chorioretinitis (TORCH) & Hge

3. Ears

- ☒ Assessment of gestational age (cartilage)
- ☒ Abnormal shape (congenital anomalies)
- ☒ Low set ears: Helix meets the cranium at lower level (horizontal level of inner canthi)

4. Nose

- ☒ Choanal atresia (RD, Obligatory nose breathers, Crying…)
- ☒ Flattening: Potter's facies

5. Mouth

- ☒ Tongue tie
- ☒ Excessive drooling of saliva (TOF)
- ☒ Lingual thyroid
- ☒ Natal tooth (remove if loose to avoid aspiration)
- ☒ Cleft palate
- ☒ High arched palate

6. **Jaw:** Micrognathia (Pierre-Robin syndrome)
7. **Face:** facial palsy, trisomies, dysmorphism…

8. Neck

☒ Webbing (Turner)
☒ Goiter
☒ Sternomastoid tumor
☒ Fracture clavicle

9. Chest

☒ Nipples (widely separated in Turner)
☒ Areola (assessment of gestational age)
☒ Deformities (pectus excavatum & carinatum)
☒ Intestinal sounds (Diaphragmatic hernia)

10. Heart

☒ HR = 120-160
☒ Murmurs

Hart murmur may be CHD *(chance is 1:12)*
Innocent murmurs are **much more frequent**

The most common innocent murmur in neonates is **pulmonary flow murmur**

11. Abdomen

☒ Scaphoid (Diaphragmatic hernia)
☒ Ascite (Urinary ascites, chylous…)
☒ Abdominal mass (DD: *mention*)
☒ Absent abdominal wall muscles (Prune-Belly $)
☒ Liver, tip of spleen & lower pole of the kidney (may be *normally* felt)

12. Genitalia

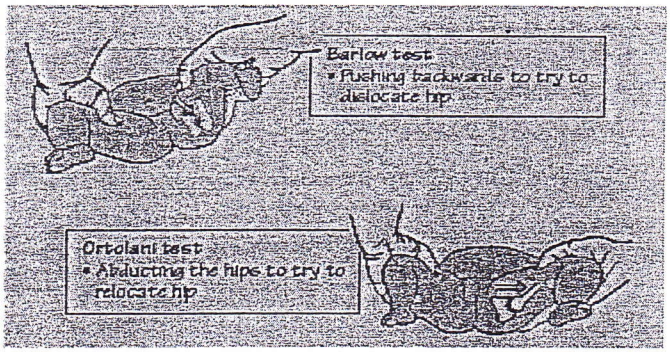
☒ Hypospadias (avoid circumcision)
☒ Atypical genitalia (CAH)
☒ Interrupted urine stream (PUV)
☒ Penile erection is normal

13. Back

☒ Meningomyelocele
☒ Spina bifida occulta (lipoma, tuft of hair, sinus…)

14. Extremities (musculoskeletal system)

☒ Absent radius (TAR)
☒ Thumb anomalies (Fanconi anemia)
☒ Talipes
☒ Erb's palsy & fractures
☒ Polydactyly, syndactyly
☒ DDH (developmental dysplasia of the hip)
Routine tests: Barlow & Ortolani ⇒



15. Skin

☒ Pallor, jaundice, cyanosis, plethora
☒ Lanugo hair: ↑↑ in preterm babies
☒ Vernix caseosa: white, greasy, waxy substance covering the skin (↑↑ in preterm babies)
☒ Macular hemangioma: usually on the upper eyelids, bridge of the nose & forehead
☒ Milia: small yellowish white papules over the nose & checks (disappear within weeks)
☒ Mongolian spots: Bluish areas of pigmentation over the back &buttocks (disappear 1-2 yrs)
☒ Erythema toxicum: erythematous macules, papules & vesicles usually on the trunk. Contains eosinophils (? allergic). Cultures are sterile.
☒ Transient pustular melanosis: vesiculopustular eruption in the chin, neck, palms & soles. Contains PNLs. Cultures are sterile.
☒ Edema *(causes of hydrops)*
☒ Hyperpigmentation: CAH, Fanconi anemia, café-au-lait spots, McCune-Albright $
☒ Hypopigmentation: Albinism, tuberous sclerosis, Chediak-Higashi $
☒ Neurocutaneous syndromes: NF, TS, Sturge-Weber
☒ Scaly skin lesions: icthyosis, acrodermatitis enteropathica
☒ Vesiculobullous diseases: epidermolysis bullosa
☒ Dermal sinuses: thyroglossal, preauricular, pilonidal & branchial sinus

16. Anus & Rectum

☒ Patency should be checked
☒ Passage of meconium

17. Neurologic

☒ Full neurologic examination ☒ Neonatal reflexes

18. Assessment of Gestational age

Assessment of gestational age—new Ballard score

Neuromuscular Maturity

Score	−1	0	1	2	3	4	5
Posture							
Square window (wrist)	> 90°	90°	60°	45°	30°	0°	
Arm recoil		180°	140–180°	110–140°	90–110°	< 90°	
Popliteal angle	180°	160°	140°	120°	100°	90°	< 90°
Scarf sign							
Heel to ear							

Physical Maturity

Skin	Sticky, friable, transparent	Gelatinous, red, translucent	Smooth, pink; visible veins	Superficial peeling and/or rash; few veins	Cracking, pale areas; rare veins	Parchment, deep cracking; no vessels	Leathery, cracked, wrinkled
Lanugo	None	Sparse	Abundant	Thinning	Bald areas	Mostly bald	
Plantar surface	Heel-toe 40–50 mm: −1 < 40 mm: −2	> 50 mm, no crease	Faint red marks	Anterior transverse crease only	Creases anterior 2/3	Creases over entire sole	
Breast	Imperceptible	Barely perceptible	Flat areola, no bud	Stippled areola, 1–2 mm bud	Raised areola, 3–4 mm bud	Full areola, 5–10 mm bud	
Eye/Ear	Lids fused loosely: −1 tightly: −2	Lids open; pinna flat, stays folded	Slightly curved pinna, soft, slow recoil	Well curved pinna, soft but ready recoil	Formed and firm, instant recoil	Thick cartilage, ear stiff	
Genitals (male)	Scrotum flat, smooth	Scrotum empty, faint rugae	Testes in upper canal, rare rugae	Testes descending, few rugae	Testes down, good rugae	Testes pendulous, deep rugae	
Genitals (female)	Clitoris prominent, labia flat	Clitoris prominent, small labia minora	Clitoris prominent, enlarging minora	Majora and minora equally prominent	Majora large, minora small	Majora cover clitoris and minora	

Maturity Rating

Score	Weeks
−10	20
−5	22
0	24
5	26
10	28
15	30
20	32
25	34
30	36
35	38
40	40
45	42
50	44

Scores from neuromuscular and physical domains are added to obtain total score.

Neuro-muscular system	physical
Posture	Skin
Square window	Lanugo
Arm recoil	Plantar creases
Scarf sign	Breast
Polpliteal angle	Eye/ear
Heel to ear	Genitalia (♂ & ♀)

Nursery Care of the Well Newborn

1. **Hand Washing** (using Sterillium)
2. **Maintenance of bode Temperature**
   - Skin-to-skin with the mother (Kangaroo care)
   - Radiant warmer (servo control)
3. **Check**
   - ☒ Vital signs (RD)
   - ☒ Color (Pallor, cyanosis, jaundice)
   - ☒ Jitteriness (↓↓ glucose, ↓↓ Ca)
4. **Care of the skin**
   - Sterile cotton soaked with fresh warm tap water to remove blood, meconium
   - 1st bath is delayed till stabilization of temperature
5. **Care of the cord** (using Alcohol 70%)
6. **Care of the Eye** (prophylactic eye drops)
7. **Vitamin K** (0.5-1 mg **IM***, alternatively, several <u>oral</u> doses *may* be given)
8. **Complete physical examination** (vital signs, measurements, systemic, gestational age)
9. **Urine & Stools**
10. **Immunization** (BCG & HBV ± HBIG)
11. **Neonatal screening**
    - Hypothyroidism, Galactosemia, PKU & Hemoglobinopathies
    - Medium chain acyl-CoA dehydrogenase (MCAD
    - Cystic fibrosis (in UK)
12. **Hearing screen** (for congenital hearing loss)
13. **Glucose screening** (for IDM, LGA & SGA)
14. **Bilirubin screening** (serum or transcutaneous measurement)
15. **Cord blood** (can be saved for 2 wks): Blood group & Coombs test
    - Rh –ve mother
    - Neonatal jaundice in the 1st 24 hrs
    - Previous infant with Coombs positive hemolytic anemia
16. **Circumcision**
    <u>Benefits</u>: ↓↓ UTI, cancer penis & STDs
    <u>Complications</u>: Bleeding & infection *(bleeding profile is require if <u>+ve family history</u>)*
    <u>Contraindications</u>: Hypospadias, ambiguous genitalia, unstable clinical status
    <u>Analgesia</u>: Nerve block & EMLA cream *(Sucrose 24% pacifier is used as adjuvant)*
17. **Early Feeding**
    - Breastfeeding should be initiated ASAP preferably in the delivery room (8-12 times/day)
    - Artificial feeding: every 3-4 hours
18. **Discharge & Follow-up**
    - ☒ NVD
    - ☒ Uncomplicated delivery
    - ☒ Singleton, FT, AGA
    - ☒ Stable vital signs in open cot ≥ 12 hr
    - ☒ Urine, stool ≥1
    - ☒ Feeding ≥ 2
    - ☒ Normal physical examination
    - ☒ No NJ in the 1st 24 hr
    - ☒ No excessive post circumcision bleeding
    - ☒ Completion of metabolic screening
    - ☒ Vaccination (HBV)
    - ☒ Maternal competence in routine neonatal care
    - ☒ No social risk (teen mother, history of child abuse)
    - ☒ F/U arrangement

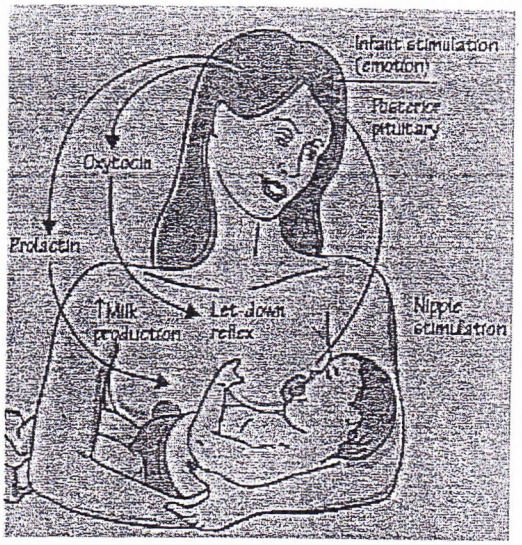
Criteria for admission to the nursery:
1. Well-appearing neonate
2. ≥ 35 weeks
3. ≥ 2 Kg

Healthy newborns should be with their mothers all or near all the time

Urine: 1st 30 hours
Meconium: 1st 48 hours

Infants born to HBsAg +ve mother should receive **both** HBV & HBIG within 12 hr

Breastfeeding



Breast is the best

Advantages

A) To the mother

1. Prevention of postpartum He (oxytocin)
2. Contraceptive value
3. ↓↓ Risk of breast cancer & osteoporosis
4. Economic

B) To the Baby

1. Psychological (Mother-infant bonding)
2. ↓↓ Risk of atopy, obesity, type 1 DM
3. ↓↓ Incidence of NEC
4. ↑↑ IQ
5. GIT growth factors
6. Anti-infective properties

- Sterile
- IgA (Surface immunity)
- Lysozyme (Dissolves bacterial cell wall)
- Lactoferrin (Binds iron & B_{12})
- Anti-Staph. Factor
- Lactobacillus bifidus promoting factor → ↑↑ Lactobacilli → ↓↓ E.coli
- Cells: lymphocytes & macrophages

7. Nutritional
   - High nutritive value
   - Proper unique composition

Item	Composition	Comments	Preterm Breast milk
Energy	67 Kcal/dL		67 Cal/dL
Proteins	1.25 g/dL	Whey predominant (4:1)	1.8-2.4 g/dL
CHO	7 g/dL	Lactose	6 g/dL
Fat	3.9 g/dL	↑↑ content of essential FA	3.9 g/dL
Ca	28 mg/dL	Ratio 2:1 is optimal for absorption	15 mg/dL
P	14 mg/dL		14 mg/dL
Na	7 mEq/L	*Breast milk has a lower Na content*	22 mEq/L
K	15 mEq/L		18 mEq/L
Iron	0.03 mg/dL	Iron stores are sufficient for 2 m	
Vitamin A	225 IU/dL		
Vitamin D	2 IU/dL		
Vitamin E	0.4 IU/dL		

Hind milk contains more fat than foremilk

10 Steps for Successful Breastfeeding

1. Have a written **policy**
2. **Training** of health care providers
3. **Educate** all pregnant mothers (Benefits)
4. Help to **initiate** breastfeeding within 1/2 hr
5. **Show how** to breast-feed
6. **Rooming-in** (mother & infant together)
7. **Exclusive**
8. **On demand** feeding
9. **No pacifiers**
10. Breastfeeding **support groups**

Expression & Storage of Breast Milk

- ☒ Hand washing
- ☒ Sterilization of milk collection equipment
- ☒ Expression using a pump
- ☒ Plastic containers are usually used
- ☒ Labeling the container with the name & date
- ☒ The amount should be suitable for single feed

▪ Fresh unrefrigerated milk	1 hour
▪ Stored fresh (4°C)	1-2 days
▪ Freezing	6 months

Contraindications of Breastfeeding

Conditions that are Not CI:
- HCV (No evidence of milk transmission)
- HBV (Give: HBV + HBIG)
- Fever
- Smoking (But advise the mother)

1. Inborn errors of metabolism: Galactosemia & PKU
2. Breast milk jaundice
3. Maternal infection
   - ☒ Open TB (Expressed breast milk can be given)
   - ☒ CMV in extremely preterm babies
   - ☒ HIV
   - ☒ Human T Cell Lymphotropic Virus (HTLV-1 & HTLV-2)
4. Maternal medications
   Most drugs are secreted in breast milk in small amount that do not affect the baby
   Whenever possible, all drugs should be avoided during breastfeeding

Contraindicated	Avoid or give with caution	Probably Safe
Antineoplastics	Aspirin	Acetaminophen
Amiodarone	Alcohol	Antibiotics
Bromocriptine	OCPs	Antiepileptics
Cyclophosphamide	Estrogen	Anesthetics
Cocaine	Laxatives	Antihistaminics
Chloramphenicol	Metoclopramide	Diuretics
Diethylstilbestrol		Digoxin
Ergots		Theophylline
Heroin		Insulin
Lithium		Prednisone
Methotrexate		Propylthiouracil
Methimazole		Propranolol
Radioactive Iodine		Vitamins
Tetracycline		Warfarin

Disadvantages of Breastfeeding

- ☒ Amount taken by the baby can not be determined
- ☒ Breast milk jaundice
- ☒ Without fortification, breast milk is not suitable for preterm
- ☒ Breast engorgement, fissured nipple & mastitis
- ☒ Transmission of some diseases (HIV, CMV, HTLV, GBS, Listeria monocytogenes)

Premature neonates require more proteins, Ca & PO_4

Colostrum

- Breast milk in the 1st 2-3 days
- Daily amount = 60 cc
- High protein content = 8 g/dL
- Value: nutritive (↑↑ proteins) & protective (IgA)

Prematurity

Classification of Newborns

A) Gestational age classification

- Preterm: delivery before 37 weeks
- Term: 37-42 weeks
- Post-term: ≥ 42 weeks

B) Birth weight classification

- Macrosomia: Birth weight ≥ 4 Kg
- Normal birth weight: 2.500-3.999 Kg
- Low birth weight: < 2.500 Kg
  - → Moderately LBW (MLBW) = 1.500-2.499
  - → Very LBW (VLBW) = 1.000-1.499
  - → Extremely LBW (ELBW) < 1.000

C) Appropriateness of the weight to gestational age

- AGA: 10^{th} - 90^{th} %
- SGA < 10^{th} % for age
- LGA > 90^{th} % for age

Causes of LBW
1. Premature neonates
2. Term & post-term (SGA)

Late Preterm: 34-38 wks

Definition

Preterm baby is any neonate born before 37 weeks (< 259 days)

Incidence

- 9 %
- 75 % of neonatal mortality

Etiology of Prematurity

A) Fetal Causes

- Fetal distress
- Polyhydramnios
- PROM
- Multiple pregnancies
- Hydrops (immune & nonimmune)

B) Maternal

☒ Complications of pregnancy: PIH, antepartum hemorrhage (2)
☒ Uterine causes: Incompetent cervix, bicornuate uterus, septate uterus & fibroid
☒ Placental causes: Placental insufficiency
☒ Maternal diseases
- HTN & DM
- Renal & cardiac disease (GN, UTI, CHD…)
- Anemia & malnutrition
- Infections: GBS, Listeria…

☒ Stress, fatigue & heavy work

C) Iatrogenic *(Wrong calculation)*

D) Idiopathic

Prevention of prematurity

- Antenatal care for early diagnosis & Rx of causes of prematurity (PIH, PN, DM…)
- Avoid stress, heavy work
- Rest & proper diet
- Tocolytics (Ritodrine…) & Cerclage operation

Problems of Prematurity *(All are related to difficulty in extra-uterine adaptation)*

System	Immediate	Late
CNS	Hypoxic Ischemic Encephalopathy (HIE) Intracranial hemorrhage (ICH) Seizures Kernicterus Hypotonia	Mental retardation CP (Spastic, choreoathetotic), seizures Learning disabilities Speech & language disorders Microcephaly Hydrocephalus
Hearing & Vision	Retinopathy of prematurity	Hearing & visual impairment Myopia & squint
Respiratory system	Respiratory Failure (RDS) Apnea Pneumthorax	BPD Cor pulmonale Subglottic stenosis Iatrogenic cleft palate
Cardiac	Heart failure PDA (70% if < 1.000 gm)	HTN (Dexamethasone, renal a. stenosis)
GIT	NEC Weak suckling & swallowing	Short bowel syndrome Malabsorption, Malnutrition GERD
Hepatic	Neonatal cholestasis *(sepsis, TPN...)* Indirect hyperbilirubinemia	Cirrhosis Liver cell failure
Renal	ARF *(causes)* ↓↓ Na, ↑↑ Na, ↑↑ K, RTA, glucosurria	Nephrocalcinosis HTN *(renal artery stenosis)*
Nutritional	Nutritional deficiencies	Ostepenia, fracture & deformities FTT
Social	Social stress	Child abuse Divorce
Skin	Injury	Scars (PDA, chest tube), Hernia
Infection	Infection	Recurrent infection (pneumonia)
Hematologic	Anemia, Bleeding (↓↓ PLT, DIC, ↓↓ vit.K)	Bleeding sequelae
Metabolic	↓↓ Ca, ↓↓ Glucose Hypo& Hyperthermia	
Anomalies	↑↑ Frequency of congenital anomalies	3-7 % of LBW

Prognosis

1. **Survival:** 95% (1.5-2.5 Kg),
2. **Long-term problems** *(table)*
3. **Neurologic & Developmental disabilities** *(table)*: CP, MR...
   30-50% of VLBW have poor school performance

Discharge & Follow-up

- ☒ Weight = 1.800-2.100 Kg
- ☒ Steady wt increment (10-30 g/day)
- ☒ Stable vital signs in open cot ≥ 12 hr
- ☒ Oral intake (nipple, bottle or Ryle)
- ☒ No TPN
- ☒ No recent apnea or bradycardia
- ☒ No O_2 (some are discharged on home O_2)
- ☒ Completion of metabolic screening
- ☒ Eye examination (ROP), When? Who?
- ☒ Hearing screening
- ☒ Vaccination (No live attenuated vaccines)
- ☒ Maternal competence in neonatal care
- ☒ No social risk (teen mother, history of child abuse)
- ☒ F/U arrangement

Management of Premature Infant

A) Antenatal Management
- Prevention of prematurity
- Delivery in an equipped hospital

B) Resuscitation & Stabilization

C) Nursery Care *(See before)*

D) Neonatal Care

Estimated heat loss in neonates is 4 times that of an adult
Preterm NB is at a greater risk

1. Incubator Care

Value:
- Isolation: ↓↓ Risk of infection
- Temperature control (31-32°C) to maintain body temperature at 36.5-37°C
- Humidity (40-60%) to ↓↓ heat loss & to ↓↓ insensible water loss (from the lungs)
- Controlled oxygen supply [Injury from both hypoxia & hyperoxia should be balanced]
- Observation

Alternative to incubators: Radiant warmer, heating lamps, room temperature control

2. Hyperbilirubinemia
- Careful monitoring
- Prophylactic phototherapy

3. PDA
- Adequate oxygenation
- Fluid restriction
- Indomethacin (or ibuprofen)
- Surgical ligation

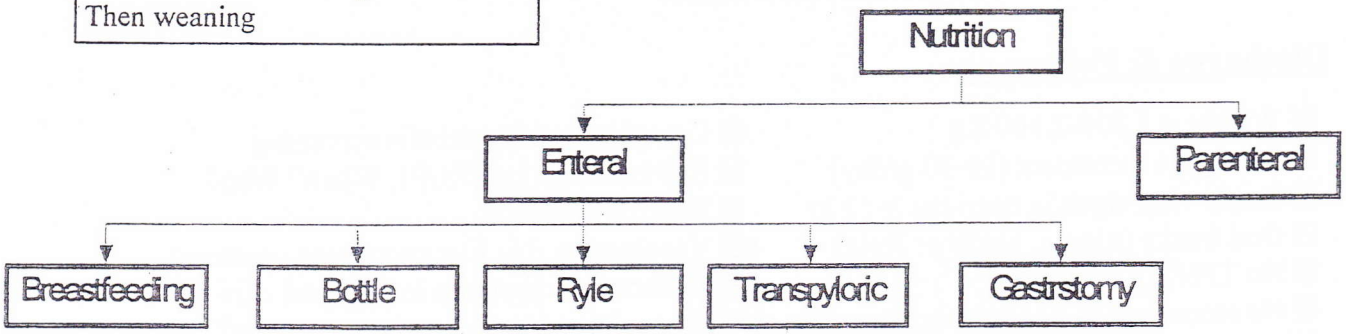
4. Infection
- Strict antiseptic precautions
- Prophylactic antibiotics
- Vaccination *(given according to the chronologic age Not the post-conceptional age)*

5. Fluid & Electrolyte therapy

6. Nutrition

Feeding of the Premature Infant

Feeding of the term infant
Exclusive breastfeeding for 6 months
Then weaning



Nutritional Requirements

Item	Requirements	Comments
Energy	120-140 Kcal/Kg/day Max = 180 Kcal/Kg/day [Maintenance of BW = 50 Weight Gain = 70-90]	▪ ↑↑ Energy intake > 180 is Not utilized for growth ▪ ↑↑ Energy ⟶ ↑↑ NH_3, BUN, Na & Acidosis ▪ ↑↑ **Energy requirements** in HF, RDS, BPD & SGA
Proteins	3.5 g/Kg/day	▪ Breast milk is inadequate for preterm & LBW ▪ ↑↑ Protein intake > 4-5 gm/Kg/d ⟶↑↑ NH_3, BUN, Na & Acidosis
CHO	11-16 g/Kg/day	
Fat	5-7 g/Kg/day	▪ Should constitute 40-50% of calories ▪ ↑↑ Fat intake ⟶ Ketosis
Water	Term = 150 cc/kg/day VLBW ≥ 200 cc/kg/day	↓↓ **Water intake with ↑↑ Calories in:** ▪ HF, RDS & BPD ▪ PDA ↑↑ **Requirements in:** ▪ Phototherapy ▪ Radiant warmer ▪ ↓↓ Humidity
Ca	100-200 mg/Kg/day	▪ Breast milk is inadequate ▪ Ca supplementation is required
P	60-120 mg/Kg/day	
Na	3-5 mEq/Kg/day	▪ Breast milk is inadequate + ↑↑ Renal loss
K	2-3 mEq/Kg/day	▪ ↑↑ Renal loss
Iron	2-4 mg/Kg/day	▪ Iron stores are adequate in term NB for 2 months ▪ Preterm require iron supplementation once they are on full enteral feeds ▪ 2-4 mg/Kg/day (for 6-12 months) ▪ For Rx: 6 mg/Kg/day ▪ Iron is an **oxidant agent**
Vitamin A	1.500 IU/Kg/day	▪ ↓↓ Incidence of BPD
Vitamin D	400-1.000 IU/day	▪ ↓↓ Incidence of osteopenia of preterm
Vitamin E	6-12 IU/Kg/day	▪ Vitamin E is an anti-oxidant ⟶ protection of PUFA in RBC membrane ▪ ↓↓ Vitamin E + Iron therapy ⟶ Syndrome of (Hemolytic anemia + Edema + Thrombocytosis) ▪ Vitamin E ⟶ ↓↓ PNL function ⟶ ↑↑ Susceptibility to sepsis ▪ Vitamin E ⟶ Hyperosmolar preparation ⟶ ↑↑ Susceptibility to NEC
Vitamin K		▪ Given routinely to all NB for # HDN (0.5-1 mg IM)
Vitamin C		Multivitamin supplementation
Vitamin B		
Folic		
Trace Elements	Zn, Cu, Mn, Selenium, Chromium, Iodine	Present in adequate amount in preterm formulas

Enteral Feeding

Feeding of the preterm infant should be **individualized**

Type of milk

1. Breast milk is recommended for preterm but needs fortification [human milk + Fortifier]
   Without fortification, breast milk is not suitable for preterm
2. Low-birth weight formula

Sign	Energy	Protein	Fat	CHO	Na	K	Ca	PO_4
Breast Milk	67 Cal %	1.25 g %	3.9 g %	7 g %	7	15	28	14
LBW formula	81 Cal %	2.2 g %	3.9 g %	8.5 g %	13-20	18	80	40

Supplementation is required:

- Vitamins (A, D, E, C, B, Folic)
- Iron (2-4 mg/Kg/day) for 6-12 months

Routes of Enteral Feeding

1. Oral (Breast & Bottle)
2. Gastric feeding (Nasogastric & orogastric enteral feeding)
3. Transpyloric feeding
4. Gastrostomy feeding

Value of Early Enteral Feeding

1. ↓↓ Risk of dehydration
2. ↓↓ Risk of hypoglycemia
3. ↓↓ Risk of hyperbilirubinemia

Glucose 5% should be used in the 1st oral feed (to exclude **TOF**)

A) Oral Feeding

Methods of oral feeding

Suck-Swallow-breath reflexes

a. Breastfeeding

It may be allowed for premature NB ≥ 34 wks gestation (Coordinated reflexes)

b. Bottle Feeding

Using expressed breast milk or LBW formula in premature NB ≥ 34 wks

Precautions of oral feeding

1. Gestational age ≥ 34 weeks (coordinated suck-swallow-breath reflexes)
2. Respiratory rate < 60/minute
3. Absence of contraindications

Small soft nipples with large holes, Why?

Contraindications of oral feeding (= Indications…)

1. Immaturity
   a. Preterm < 34 weeks (Weak suckling & swallowing)
   b. LBW < 1.500 gm (Energy loss!!)
2. CNS depression
3. Perinatal asphyxia & Hypoxia
4. Respiratory distress
5. Circulatory failure (shock, hypotension, hypothermia, poor perfusion)
6. Sepsis
7. Suspected structural anomalies (TOF, IO…)
8. Feeding intolerance

B) Gavage Feeding

Definition: Nasogastric or orogastric enteral feeding

Indication:

- Preterm < 34 weeks (Weak suckling & swallowing)
- LBW < 1.500 gm
- Contraindications of oral feeding (Except…)

Technique:

Soft plastic tube 5 French (rounded tip with 2 side holes)
The location of the tube must be checked before every meal ⟹
The measured amount is allowed to flow slowly (by **gravity**)/3-4 hr
The tube can be introduced before each feed or changed every 2-3 days

1. aspiration
2. Air bubbles
3. Cyanosis

Routes:

a. Nasogastric:

- ↑↑ Airway resistance
- ↑↑ Respiratory rate (obligate nasal breathers)
- ↑↑ Risk of otitis media
- Injury of the nasal septum
- Better fixation

b. Orogastric

Methods:

a. Intermittent (bolus)
b. Continuous: at a slow rate (CHPS, GERD, RDS…)

C) Transpyloric feeding

Technique:

Soft plastic tube is advanced beyond the pylorus into the distal duodenum or jejunum

Indication:

- Gastric retention
- GERD
- To ↓↓ risk of aspiration

Disadvantages

- Bacterial overgrowth
- Malabsorption
- Dumping effect & diarrhea (↑↑ intestinal osmolarity)
- Intestinal perforation

D) Gastrostomy Feeding

Indication:

- TOF
- Chest surgery

Signs of Feeding Intolerance

1. Bilious (greenish) or bloody (brownish) gastric residue
2. ↑↑ Residue (>25% of the previous feed)
3. ↑↑ Abdominal girth
4. Vomiting
5. Bloody stools (+ve heme test)
6. Watery stools (+ve reducing substances)

Contraindications of Enteral Feeding (Absolute)

- NEC
- Intestinal surgery
- ~~Severe prematurity~~

Gut integrity is dependent on enteral nutrition

Trophic Feeding (Gut priming or early enteral feeding)

Definition: Small amounts of enteral feeding in neonates not tolerating regular feed

Type of milk: Expressed breast milk or 1/2 or full strength LBW formula

Onset: ASAP after birth ideally on D_2 .

Volume: Start with 1 cc/6 hrs & advance slowly to 10-20 cc/Kg/day

Advantages:

- ↑↑ GIT motility
- ↑↑ GIT maturity
- ↑↑ GIT hormones
- ↓↓ Serum blirubin
- ↓↓ Time needed to establish full enteral feeding
- ↓↓ Time on TPN

Indications:

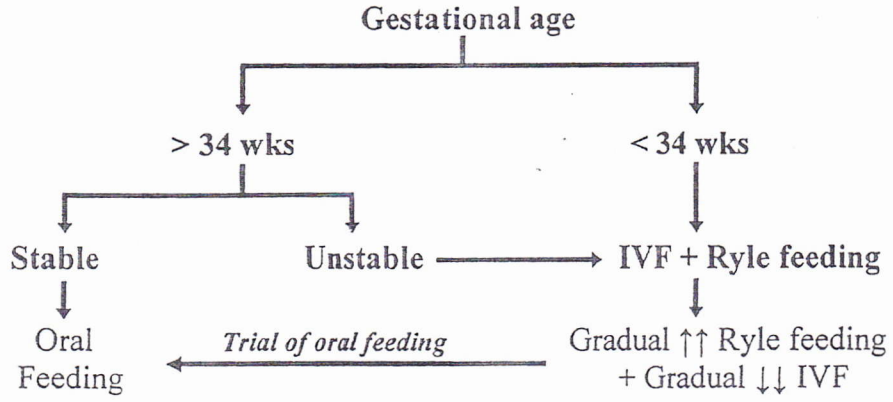
- Gut priming specially in ELBW
- Term NB with mild instability
- Umbilical artery catheter (↑↑ Risk of NEC)

Contraindications:

- NEC
- Intestinal surgery

Special considerations of Enteral Feeding

- Gut integrity is dependent on enteral nutrition, so **careful early** feeding is recommended
- Trophic feeding can be started **even** in ELBW
- Initial feeds are EBM, 1/2 or full strength
- Start with small volumes then ↑↑ gradually guided by the available protocols & tolerance
- The daily volume increments should not exceed 10-20 cc/Kg/day
- Aim = 150 cc/Kg/day = 120 Kcal/Kg/day
- The remaining part of the total fluid requirements is given as parenteral nutrition (TPN or IV fluids)



Assessment of Nutrition & Growth

A) Clinical

- Weight *(daily)*
- Length *(weekly)*
- Head circumference *(weekly)*

B) Laboratory

- Serum albumin, Ca, PO_4, ALP, Hb

Parenteral Feeding

A) Intravenous Fluids (Partial parenteral nutrition)

Indications: (Almost all preterm NB require IVF)

- ☒ Transient till establishment of adequate enteral feeding (preterm, sick term NB…)
- ☒ Contraindications of enteral nutrition (NEC, intestinal surgery…). If enteral intake is not expected for > 3 days, TPN should be used

Fluid Requirements (cc/Kg/day)

	G%	Day 1	Day 2	Day 3	D 4 & over…
≥ 2.500 gm	10%	60-80	90	100	↑↑ by 10 cc/Kg/day till 150 cc/Kg/day
1.500-2.500 gm	10%	80	100	110	↑↑ by 10 cc/Kg/day till 150-180 cc/Kg/day
1.000-1.500 gm	7.5%	100	120	130	
< 1.000 gm	5%	120	140	170	

- **Subtract** 20 cc/Kg/day in case of RD
- **Add** 20 cc/Kg/day in case of phototherapy, radiant warmer or fever

Electrolyte Requirements

	Day 1	Day 2	Day 3
Na	-	2-3 mEq/Kg/day	2-3 mEq/Kg/day
K	-	1-2 mEq/Kg/day	1-2 mEq/Kg/day
Ca	35 mg/Kg/day	35 mg/Kg/day	35 mg/Kg/day

- Do not add Na if serum Na > 140 mEq/L
- Do not add K if serum K > 4.5 mEq/L
- Do not add K until urine output is established
- Use Glucose 5-10%

3 mEq/Kg/day = NS 20 cc/Kg/day
This volume is subtracted from total IVF

Ca: 35 mg/Kg/day = 4 cc/Kg/day

Assessment of hydration status of NB

A) Clinical

- Weight
- Skin
- Fontanel
- Urine volume

B) Laboratory

- Serum Na
- Urine: Specific gravity & Glycosuria

Example

Any enteral feeds should be subtracted from the total volume

Calculate the IVF of a preterm neonate 2 Kg

Day 1: Total volume = 160 cc
Type of fluids = 150 cc Glucose 10% + 8 cc Ca gluconate

Day 2: Total volume = 200 cc
Type of fluids = 150 cc Glucose 10% + 8 cc Ca gluconate + 40 cc NS + 1 cc KCl

Day 3: Total volume = 220 cc
Type of fluids = 170 cc Glucose 10% + 8 cc Ca gluconate + 40 cc NS + 1 cc KCl

Day 4: Total volume = 240 cc
Type of fluids = 190 cc Glucose 10% + 8 cc Ca gluconate + 40 cc NS + 1 cc KCl

Day 5: Total volume = 260 cc
Type of fluids = 210 cc Glucose 10% + 8 cc Ca gluconate + 40 cc NS + 1 cc KCl

B) Total Parenteral Nutrition (TPN)

Definition:

IV delivery of energy & nutrients

Indications:

☒ Short term indications (≈ 1 month)

- Prematurity if full enteral intake is not expected within 3-7 days
- Congenital GIT anomalies (TOF, IO, gastroschisis, diaphragmatic hernia)
- NEC

☒ Long term indications

- Malabsorption syndromes: Congenital microvillous atrophy, Tufting enteropathy…
- Short bowel syndrome
- Inflammatory bowel syndrome

Vascular Access

1. Peripheral veins
   Only iso-osmolar solution can be used (Glucose % should not exceed 12.5%)
   It is the route of choice for intralipids
2. Central veins
   - Surgically inserted (Subclavian or internal jugular vein)
   - PICC (peripherally inserted central catheters) into SVC or IVC
3. AV fistula (in long term indications)

Solutions of TPN

1. Glucose: [1 gm = 3.4 Kcal]
2. Amino acids: [1 gm = 3.4 Kcal]
3. Intralipids: [1 gm = 10 Kcal]
4. Electrolytes (Na, K, Ca, PO_4, Mg, Mn, Cu, Fe, Se)
5. Vitamins (fat-soluble & water-soluble)

Requirements

	Initial dose	Subsequent adjustment
Fluid	60-80 cc/Kg/day	↑↑ by 10 cc/Kg/day till 150 cc/Kg/day
Energy	Term = 120 Kcal/Kg/day Preterm = 120-140 Kcal/Kg/day	
Glucose	6-8 mg/Kg/min	↑↑ the rate up to 10-14 mg/Kg/min
Proteins	0.5-1 gm/Kg/day	↑↑ by 0.5 up to 2.5-3 gm/Kg/day
Lipids	0.5-1 gm/Kg/day	↑↑ by 0.5 up to 2.5-3 gm/Kg/day
Electrolytes	Added according to the daily requirements [Na = 2-3 mEq/Kg/day, K = 1-2 mEq/Kg/day, Ca = 35 mg/Kg/day …]	
Vitamins		

Complications

A) VA-related complications

- Insertion: arterial injury, pneumothorax & hemothorax
- Infection (local & systemic)
- Thrombosis
- Dislodgement
- Bleeding (Heparin)

B) Metabolite-related complications

1. **Glucose metabolism**
   - Hyperglycemia
   - Glycosuria ⟶ Osmotic diuresis ⟶ Dehydration
2. **Protein metabolism**
   - Hyperammonemia (encephalopathy)
   - Hypermethioninemia
   - Metabolic acidosis
3. **Lipid metabolism**
   - Hyperlipidemia
   - ↓↓ Essential FA (Linoleic, Linolenic…)
   - Sepsis (↓↓ PNL phagocytic activity)
   - Bleeding (Platelet dysfunction = Adhesion defect)
   - Hypoxia (↓↓ O_2 diffusion)
   - Cholestasis, fatty liver, GB stones
4. **Electrolyte disturbances**
5. **Metabolic bone disease** (Ca & PO_4 disturbances)
   Cause: Ca & PO_4 disturbances
   C/P: Rickets-like
   Lab: ↑↑ ALP
   X-rays: Rickets
6. **Vitamin deficiency**
7. **GIT:** (Appear when enteral feeding is resumed)
   - ↓↓ GIT motility
   - ↓↓ GIT secretion (gastric, pancreatic & intestinal)
   - ↓↓ Enzymatic activity (Brush border)

Feeding
↓
Intestinal mucosa
↓
Cholecystokinin
Secretin
Motilin
↓
↑↑GB Contraction
↓
↓↓ Cholestasis

Cholestasis associated with TPN

Risk factors

- Prematurity (15% in preterm < 32 wks)
- Duration (usually > 2 wks)
- Lack of enteral intake (No bile flow) ⟹
- Ileal resection (↓↓ Enterohepatic circulation)

Pathogenesis

1. Concomitant condition: infection, hypoxia, drugs…
2. Fasting (↑↑ Risk of cholestasis)
3. Amino acids in TPN
   - Methionine (↓↓ Bile flow)
   - Tryptophan (Photodegradation products of tryptophan are hepatotoxic)
4. ↓↓ Essential FA & Carnitine
5. ↓↓ Taurine (↓↓ Bile salt synthesis)
6. Formation of biliary sludge

Protection from light

Clinical Picture

Jaundice ± HSM

Investigations

Conjugated hyperbilirubinemia, ↑↑ ALT, AST & GGT

Treatment

Rx of risk factors
↑↑ Enteral feeding

Side Effects of Drugs given to Preterm Infants

	Drug	Effect
1	**Aminoglycosides**	Nephrotoxicity, Ototoxicity
2	**Amphotericin B**	Nephrotoxicity, DI
3	**Chloramphenicol**	Grey baby syndrome
4	**Tetracycline**	Enamel hypoplasia, pigmentation of teeth
5	**Sulfonamide**	Hyperbilirubinemia, hemolysis in G6PD deficiency
6	**Vitamin K**	Hyperbilirubinemia
7	**ACE inhibitors** (Captopril)	Renal impairment, oliguria
8	**Indomethacin**	Renal impairment, oliguria, bleeding, perforation
9	**Oxygen**	ROP, BPD
10	**Prostaglandins**	Apnea, Bradycardia
11	**Dexamethasone**	HTN, GIT bleeding, Hyperglycemia
12	**Furosemide**	Ototoxicity, Nephrocalcinosis
13	**Tolazoline**	Hypotension
14	**$NaHCO_3$**	IVH
15	**Phenobarbitone**	Drowsiness
16	**Heparin**	Bleeding
17	**Calcium**	SC necrosis
18	**Iodine antiseptics**	Neonatal goiter, Hypothyroidism
19	**Erythromycin**	Pyloric stenosis

Large for Gestational Age (LGA)

Definition

Infant weight > 90th % for age (2 SD above the mean for gestational age) or ≥ 4.000 gm

Etiology

1. IDM
2. Constitutional
3. Some post-term infants
4. Hydrops
5. Beckwith-Wiedemann syndrome

Complications

1. Birth injury
2. Polycythemia
3. Hypoglycemia
4. Congenital anomalies

Management

A) **Antepartum Management**
- Antenatal care for early diagnosis & Rx of DM & hydrops and for assessment of G.Age
- Delivery in an equipped hospital

B) **Intrapartum Management**
- Resuscitation & Stabilization
- Careful delivery to avoid birth injury

C) **Postpartum Management**
- Nursery care *(as before)*
- Diagnosis & Rx of potential complications...

Intrauterine Growth Retardation (IUGR)

(SGA)

Definition

Infant weight < 10th % for age (2 SD below the mean for gestational age)

Types

	Symmetric IUGR	Asymmetric IUGR**
Pattern	Continuous low profile pattern	Late flattening pattern
Onset of IUGR	Early in pregnancy	Late (3rd trimester)
Features	Length, wt & skull circumference are **equally** affected	Head is **spared** (relatively large)
Causes	▪ Chromosomal disorders ▪ Congenital infection (TORCH) ▪ Congenital anomalies ▪ Radiation ▪ Severe placental insufficiency	▪ Placental insufficiency *(mention)* ▪ Maternal causes of IU asphyxia (??) ▪ Maternal malnutrition ▪ Multiple pregnancies
Perinatal asphyxia	Usually absent	Usually present
Low Apgar score		
N. Hypoglycemia		

Complications

1. IU fetal hypoxia (fetal distress)
2. Perinatal asphyxia
3. PPHN
4. MAS
5. Polycythemia
6. Hypothermia (↓↓ Energy, ↓↓ SC)
7. Hypoglycemia & Hypocalcemia
8. Congenital infection, anomalies, chromosomal

Management

A) Antepartum Management

- Antenatal care for early diagnosis & Rx of causes of placental insufficiency (PIH, HTN...)
- Proper assessment of gestational age
- Antepartum assessment of fetal well being (= Diagnosis of placental insufficiency??)
- Assessment of fetal functional maturity (lung maturity, how?)
- Early delivery (if the risk of IU hypoxia is > risk of prematurity)
- Steroids for prevention of RDS
- Delivery in an equipped hospital

B) Intrapartum Management

- Intrapartum assessment of fetal well being??
- Resuscitation & Stabilization
- Proper management of expected complications (MAS, perinatal asphyxia...)

C) Postpartum Management

- Nursery care *(as before)*
- Early feeding is important (↓↓ Glucose)
- Diagnosis & Rx of potential complications…

Prognosis

- Depends on the etiology
- Lower risk of neonatal mortality than preterm infants with the same weight
- Potential complications…

Post-Term Infants

Definition

Post-term baby is any neonate born ≥ 42 weeks (≥ 294 days)
Post-mature baby is any neonate born ≥ 41 weeks (≥ 287 days)
Postmaturity syndrome = Post-term + Placental insufficiency

Etiology (Unknown*)

1. Miscalculation
2. Associations: anencephaly, trisomies (18, 16), multigravidity, IDM

Clinical Picture

A) Placental insufficiency

- Skin: pale, dry, wrinkled, absent lanugo hair & vernix caseosa with loss of SC fat
- Hair: abundant scalp hair
- Nails: long
- Meconium staining ± MAS
- Unusual degree of alertness
- Complications: MAS, PPHN, perinatal asphyxia, HIE, polycythemia, ↓↓ Ca, ↓↓ Glucose

B) No placental insufficiency

- ↑↑ Birth weight, head (well ossified & less moldable)
- ↑↑ Incidence of dystocia

Management

A) Antepartum Management

- Antenatal care
- Proper assessment of gestational age
- Antepartum assessment of fetal well being (= Diagnosis of placental insufficiency??)
- Delivery in an equipped hospital

B) Intrapartum Management

- Resuscitation & Stabilization
- Intrapartum assessment of fetal well being

C) Postpartum Management

- Nursery care *(as before)*
- Early feeding is important (↓↓ Glucose)
- Diagnosis & Rx of potential complications...

Prognosis

- Higher risk of neonatal mortality than term infants with the same weight
- Potential complications…

Multiple Pregnancies

Incidence

- Twins = 1: 86 Triplets = 1: 86^2 Quadruplets = 1: 86^3
- 1/3 of twins are monozygotic (MZ) = Uniovular = Identical
- 2/3 of twins are dizygotic (DZ) = Binovular = Non-identical
- The incidence of MZT is relatively constant
- The incidence of DZT is affected by:
  - -Maternal age & parity (↑↑)
  - -Use of reproductive technology (clomiphene, In vitro fertilization)

Chorion is formed around D_3
Amnion is formed around D_8

Etiology

☒ Monozygotic twins: develop from **splitting** of a single zygote (single fertilized ovum)

Splitting	Freq.	Placenta	Chorion	Amnion	Cords	Term
1st 3 days	25	2	2	2	2	Dichorionic-diamniotic
Days 4-8*	75	1	1	2	2	Monochorionic-diamniotic
Days 9-15	-	1	1	1	2	Monorionic-monoamniotic
> D 15	-	1	1	1	2	Conjoined twins

Conjoined twins (Craniopagus, thoracopagus…)

☒ Dizygotic twins: develop from 2 fertilized ova [2 ova + 2 sperms]
Always Dichorionic-Diamniotic

Genetic Consideration

- MZT have the same genotype (one fertilized ovum)
- DZT have different genotypes (two fertilized ova)

Diagnosis of Zygosity (depends on sex, placenta, blood group & HLA typing)

Type		MZT	DZT
Etiology		Splitting of a single zygote (One ovum)	Develop from 2 fertilized ova
Placenta & Fetal membrane		▪ 75% are (Monochorionic-diamniotic): [1 Placenta + 1 Chorion + 2 Amnions] ▪ 25% are (Dichorionic-diamniotic): [2 Placentas + 2 Chorions + 2 Amnions]	Always Dichorionic-diamniotic [2 Placentas + 2 Chorions + 2 Amnions]
Markers	Sex	The same	May be different
	Hair	The same color & texture	"
	Eye	The same color	"
	Blood group	The same	"
	HLA group	The same	"
Skin grafts		Well accepted	Rejected if different HLA
Dermatoglyphics		Homolateral hands are more similar than both hands of the same co-twin	Homolateral hands are less similar than both hands of the same co-twin

IU growth

- Till 29 wks of gestation ⟶ The same weight as singleton (of the same GA)
- After 33 wks of gestation ⟶ The weight of each twin is less than the singleton
- Average weight at term = 2.600 gm [average singleton = 3.200 gm]

Diagnosis of Multiple Pregnancies

a. Examination: Fundal level
b. Imaging: U/S

Complications

A) Maternal

- Abortion
- Hyperemesis gravidarum
- PIH
- Polyhydramnios
- PROM
- Pressure symptoms

B) Fetal

- Prematurity
- IUGR
- Abnormal presentation
- Congenital anomalies (more with MZT), Why?
- Asphyxia

C) 2nd Twin (↑↑ Mortality)

- Retained 2nd twin
- ↑↑ asphyxia, ↑↑ anesthesia, ↑↑ RDS

Diagnosis of TTTS:
1. Hb difference ≥ 5 gm%
2. Wt difference ≥ 20%

D) Placental vascular shunts

They occur in almost all monochorionic twins & almost never in dichorionic twins

a. Artery to artery
b. Vein to vein

} *Usually with No complications*

c. Artery to vein: may cause "twin to twin transfusion syndrome"

	Donor	Recipient
Weight	Small	Large
Nutrition	Malnourished	Well nourished
Glomeruli	Small	Large
Amniotic fluid	Oligohydramnios	Polyhydramnios
Hb	Anemia (pallor)	Polycythemia (plethora)
Blood Volume	Hypovolemia	Hypervolemia
Heart size	Microcardia	Cardiac hypertrophy
Heart failure	Heart failure (anemia)	Heart failure (hypervolemia)
Hydrops	Hydrops	
Gestational Age	Prematurity	

Management

A) Antepartum Management

- Antenatal care including U/S
- Proper assessment of gestational age
- Delivery in an equipped hospital

B) Intrapartum Management

- Two teams should be present (Complications is more in the 2nd twin)
- Resuscitation & Stabilization

C) Postpartum Management

- Nursery care *(as before)*
- Determination of zygosity & family support
- Diagnosis & Rx of potential complications...

  Donor: Anemia (packed RBC)

  Recepient: Neonatal jaundice (phototherapy ± exchange transfusion)

  Heart failure (Anti-failure)

Neonatal Resuscitation

Ventilation is the key
Chest compression & drugs are rarely needed

Definition

It is a rapid sequence of steps to be initiated if there is impairment of respiration or circulation of the newborn infant. **5-10%** of newborns require some degree of resuscitation

Goals

A) **Airway:** Suction of the upper airways ± ETT
Positioning: head in the midline & slightly extended

B) **Breathing:** Tactile stimulation
Supplementary O_2
Positive pressure ventilation (bag & mask or ETT)

C) **Circulation:** Chest compression & Drugs

All through, **do not allow the newborn to get cold.**
Hypothermia:
- Acidosis
- Hypoglycemia

Equipments & Preparation

- Radiant warmer & warm towels
- Suction & suction catheters
- O_2 source (flowmeter) & O_2 tubing
- Face masks (?size) & Ambu-bag
- ETT (2.5, 3, 3.5, 4 mm)
- Laryngoscopes (0 & 1) & check light
- Syringes (1, 3, 5, 10, 50 ml)
- Umbilical catheters (5 F)
- Stethoscope
- Drugs: adrenaline, $NaHCO_3$, Ca, naloxone
- Transport incubator

Resuscitation Technique

1. Review obstetric records
2. Proper hand washing
3. Check equipments & preparation
4. Ask 5 question??
5. Keep the neonate dry, warm & in good position
6. Suction of the upper airways; mouth, nose& oropharynx (avoid vigorous suction)
7. Gentle tactile stimulation may be needed (rubbing of the back + slapping of the soles)
8. Assessment of Apgar score *(discuss)*

Sequence of intervention

A) **No asphyxia (Apgar = 8-10):** as before

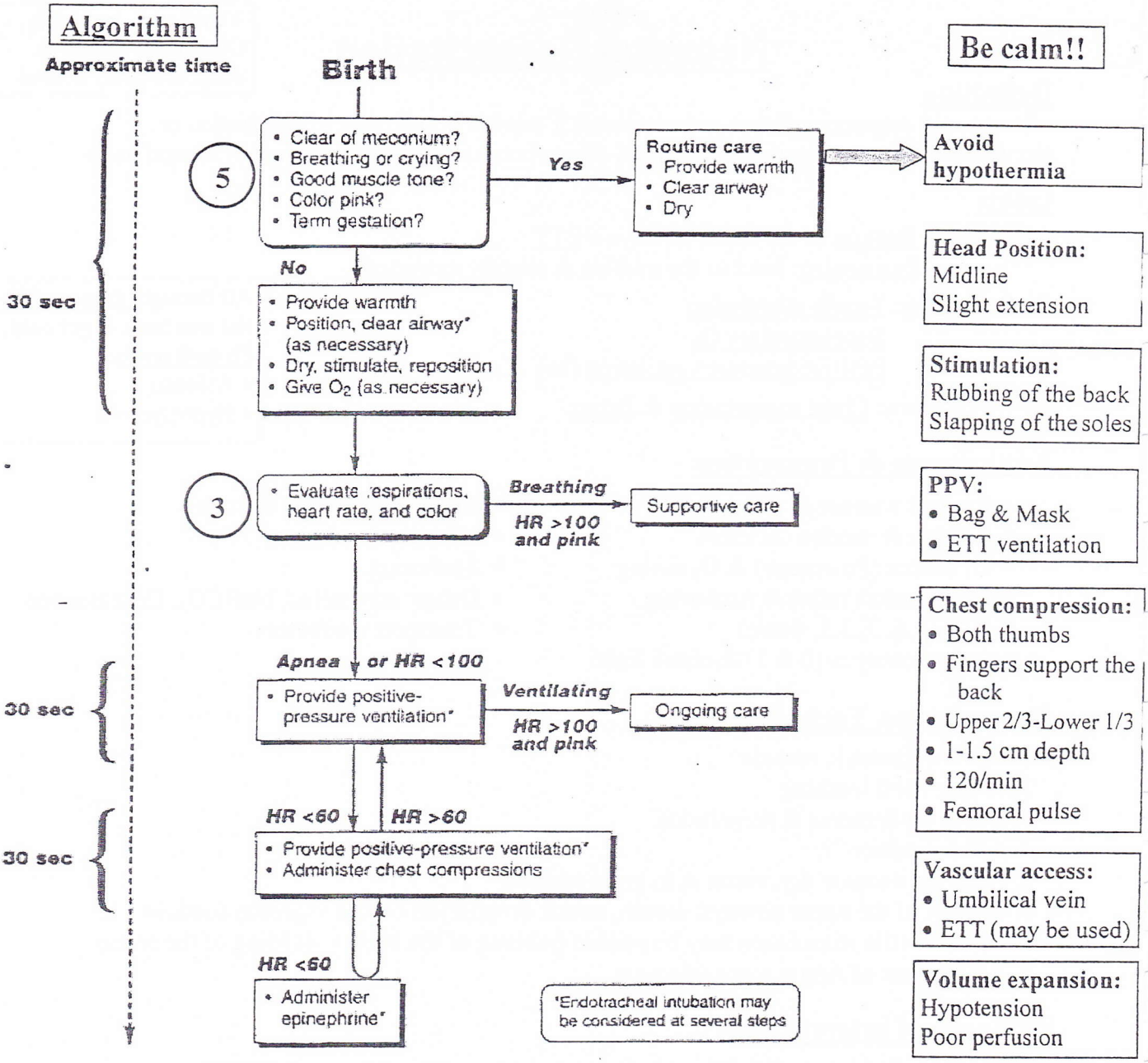
B) **Mild asphyxia (Apgar = 5-7):** [Spontaneous breathing & HR > 100/min]
⟶ Tactile stimulation + supplementary O_2

C) **Moderate asphyxia (Apgar = 3-4):** [Apnea & HR < 100/min]
⟶ Positive pressure ventilation (Bag & mask) at a rate of 40-60/min (20 cm H_2O pressure)
⟶ Reevaluation (30 sec):
a. HR > 100/min, spontaneous breathing & pink ⟶ Ongoing care
b. Apnea & HR > 60/min ⟶ Continue PPV & Reevaluate (30 sec)
c. Apnea & HR < 60/min ⟶ Consider ETT & Chest compression

Ongoing care (NICU)
- Physical examination
- CXR

Chest compression (using both thumbs; other fingers support the back) at a rate of 120/min
Compression: Ventilation ratio = 3:1
Adequacy of compression is determined by palpating the femoral pulse
Reevaluation after 30 sec of combined ventilation & chest compression
a. HR > 60/min ⟶ Stop compression & continue ventilation
b. HR < 60/min ⟶ Drugs

D) **Severe asphyxia (Apgar = 0-2):** [at any time]
Initial stabilization (dry, warm, position), suction, PPV (bag& mask), ETT, chest compression & drugs (adrenaline, $NaHCO_3$, volume expander, naloxone)



Algorithm for resuscitation of the newly born infant.

Drugs for neonatal resuscitation *(drugs are not effective unless ventilation is effective)*

Drug	Concentration	Dose	Indications
Adrenaline	1:10.000	IV: 0.1-0.3 cc/Kg ET: 0.3-1 cc/Kg	HR < 60/min after combined ventilation & chest compression
Volume expander	NS, Albumin 5% Whole blood	10-20 cc/Kg IV	Hypotension, Hypoperfusion Blood loss
Glucose	10%	2 cc/Kg IV	Hypoglycemia
$NaHCO_3$	5% & 8.4%	1-2 mEq/Kg *(slowly)*	Prolonged arrest
Naloxone	0.4 mg/ml	0.1-0.3 cc/Kg IV or ET	Maternal morphine

Indications of ETT

1. Airway patency (goiter, micrognathia)
2. Tracheal suction (MAS)
3. Ineffective bag & mask ventilation
4. Drugs & Surfactant therapy
5. Prolonged ventilation needed

Duration of Resuscitation 15-20 minutes

Causes of low Apgar:

1. Intra-partum asphyxia
2. CNS depression (anesthesia)
3. CNS anomalies
4. Congenital myopathy
5. Congenital neuropathy
6. $MgSO_4$
7. Trauma (spinal cord)
8. Hypovolemia

Infant Transport

Definition

It is neonatal transfer of high-risk infants delivered at a hospital without advanced services to a tertiary care center (Level III)

Indications

1. Prematurity (< 32 wks) &/or LBW (< 1.500 gm)
2. RD requiring ventilatory support
3. CHD or cardiac arrhythmias
4. Severe HIE
5. Congenital anomalies
6. Metabolic diseases
7. Surgical emergencies (TOF…)

Requirements

A) Transport personnel

- Team of at least 2 trained individuals (physician & nurse)
- Experience required: IV cannulation, intubation & chest tube placement

B) Medications	C) Supplies	D) Equipments
Adrenaline	Alcohol (Steryllium)	Transport incubator
Atropine	Betadine	Monitors (HR, BP, O_2%, Temp.)
$NaHCO_3$	Gauze & dressings	Suction device
Calcium	Gloves, gowns	Infusion pumps
Dexamethasone	IV Catheters (22, 24 gauge)	Laryngoscopes (Blades 0 & 1)
KCl	Butterfly needles	Magill forceps
	Umbilical catheters (5 F)	Ventilation bag
Albumin 5%	Syringes (1, 3, 5, 10, 50 ml)	Stethoscope
Glucose 10% & 50%	IV tubing	Tanks of O_2 & compressed air
Sterile water	Stopcocks	Source of electrical power
	Suction catheters (6, 8, 10 F)	Mechanical ventilator
Dopamine	Feeding tubes (5, 6, 8 F)	
Dobutamine	ETT (2.5, 3, 3.5, 4 mm)	
Digoxin	Face masks (preterm & term)	
	Airways	
Phenobarbitone	Oxygen tubing	
Phenytoin	Chest tubes (10, 12 F)	
Midazolam	Tape	
	Lubricating gel (K-Y)	
Ampicillin	Scalpel	
Gentamicin	Suture material (silk 3-0, 4-0)	
Erythromycin eye ointment	Thermometer	
PGE_1	BP cuffs	

E) Transport Vehicle: Ambulance or helicopter (if the distance > 100 miles)

It should be large enough to accommodate the team & equipments [Rapidly available]

F) Transport process:

- Consent
- Transport after stabilization
- Reassure the mother
- The father should follow the vehicle

G) Stabilization (*Before leaving the referring center*)

1. Airways: ETT may be needed
2. Breathing: O_2, mechanical ventilation, chest tube (if pneumothorax)
3. Circulation: Vascular access (peripheral or umbilical catheter)
4. Temperature
5. Metabolic stabilization: Rx of hypoglycemia
6. Hemodynamic stabilization: Volume expanders for hypotension
7. Initiation of antibiotic therapy *(after taking suitable cultures)*
8. Specific conditions
    - Diaphragmatic hernia: NGT + ETT
    - TOF: Continuous gentle suctioning from the pharyngeal pouch
    - Abdominal wall defects (gastroschisis & exomphalos major…) } ***Wrapping with warm, sterile, saline soaked gauze***
    - Neural tube defects (meningomyelocele…) }
    - Anemia: packed RBC (non-matched O –ve blood can be given)
    - Hydrops: Anemia + pleural effusion (Chest tube)
    - Congenital cyanotic heart disease (PGE_1 to maintain duct patency)

H) Post transport responsibilities

- Complete & accurate information should be given to the hospital team
- Complete documentation of the clinical course & problems surrounding the transport

Perinatal Asphyxia
(Hypoxic-Ischemic Encephalopathy)

Anoxia: Complete lack of O_2
Hypoxia: Lack of O_2
Ischemia: Lack of blood flow

Definition

Asphyxia is a condition of impaired gas exchange that leads to 3 biochemical effects:
Hypoxia, Hypercapnia & Metabolic acidosis

The term asphyxia should not be used unless all the following criteria are met:

1. Umbilical cord blood pH < 7
2. Apgar score 0-3 for ≥ 5 minutes
3. Neurological manifestations (e.g., Seizures, coma, hypotonia…)
4. Multisystem organ dysfunction

(4)

HIE is permanent brain damage due to hypoxia &/or ischemia ⟶ Death or long-term…

Incidence

1-1.5%

Etiology

A) Intrauterine causes

a. Maternal causes
- Cardiac: Heart failure, Shock
- Respiratory failure
- Severe anemia
- Hypotension (blood loss)
- Eclampsia (convulsions)

b. Placenta (Placental insufficiency) ⟹

c. Cord
- Compression (fetal head, forceps)
- Prolapse
- Ruptured vasa previa

d. Compression of fetal head
- Pelvis (Cephalo-pelvic disproportion)
- Forceps
- ICH, depressed fracture

Causes of Placental Insufficiency
- ☒ **Acute:** Placental separation (Placenta previa & accidental Hge)
- ☒ **Chronic:**
  - PIH (Pre-eclampsia)
  - Chronic HTN
  - Advanced DM
  - Placental infarction
  - Placental aging (Post-term)
  - Sickle cell anemia
  - Smoking
  - Drugs: cocaine
  - Idiopathic

B) Neonatal Hypoxia

a. CHD
b. Respiratory: (RDS…)
c. Severe anemia
d. Shock
e. CNS depression (anomalies, injury, anesthesia)

Pathophysiology

1. **Hypoxia** ⟶ anaerobic metabolism ⟶ Lactic acidosis
2. Lactic acidosis ⟶ ↓↓ glycolysis, ↓↓ cerebral autoregulation & ↓↓ cardiac function ⟶
3. Local **ischemia** ⟶ Energy failure ⟶ # Na-K ATPase activity ⟶
4. ↑↑ Intracellular Na, Cl, H_2O, Ca
5. ↑↑ Extracellular K, excitatory aminoacid neurotransmitters (glutamate & aspartate)
6. Excitatory aminoacids ⟶ ↑↑ Intracellular Na, Cl, H_2O, Ca (↑↑ entry)
7. Immediate neuronal death ⟶ Leakage of osmotic materials into the interstitial tissue
8. Vasogenic brain edema ⟶ ↑↑ Intracranial pressure ⟶ ↑↑ Ischemia *(vicious circle)*
9. Reperfusion injury

Pathology (= Topography of brain injury)

1. Cortical necrosis or infarcts } Full term
2. Selective neuronal necrosis }
3. Periventricular leukomalacia } Preterm
4. Subependymal germinal matrix hemorrhage/IVH }

Clinical Picture

- History suggestive of perinatal asphyxia (obstructed labor, FHR abnormalities, low Apgar...)
- Seizures, apnea, pallor, unresponsiveness…
- Staging of HIE (Sarnat is used in > 36 wk)
- Effects of perinatal asphyxia

Sarnat staging of HIE

	Grade 1	Grade 2	Grade 3
Conscious level	Hyperalert	Lethargy	Coma
Pupils	Mydriasis (reactive)	Miosis (reactive)	Unequal or fixed
Posture	Normal	Flexion	Decerebrate
Muscle tone	Normal	Hypotonia	Flaccid
Reflexes/Clonus	Hyperactive	Hyperactive	Absent
Myoclonus	Present	Present	Absent
Moro reflex	Strong	Weak	Absent
Seizures	No	Common	Decerebrate
EEG	Normal	Low-voltage	Isoelectric
Duration	< 24 hr	1-14 days	Days to weeks
Prognosis	Good	Variable	Death, severe deficits

Effects of perinatal asphyxia

System	Effects	Investigations
CNS	HIE ICH Infarction Seizures Brain edema Hypertonia/hypotonia	▪ EEG &Amplitude EEG (aEEG) ▪ Cranial US ▪ MRI, MRS, CT (may be normal on D_{1-2}) ▪ Visual evoked potentials (VEP) ▪ Auditory brain stem response ▪ ↑↑ Creatine kinase (brain fraction; CK-BB)
CVS	Myocardial dysfunction Hypotension Arrhythmias Acidosis	▪ ECG *(raised ST segment)* ▪ Echocardiography ▪ Myocardial enzymes ▪ Blood gases
Respiratory	PPHN, RDS, MAS Hypoxemia & Acidosis	▪ Blood gases ▪ CXR
Renal	ATN & Cortical necrosis Oliguria / Polyuria	▪ KFT (BUN & creatinine) ▪ Urine osmolarity, Fractional excretion of Na
GIT	Feeding intolerance & NEC Liver damage	▪ Occult blood in stools ▪ Liver enzymes & LFTs
Blood	DIC	▪ CBC ▪ Coagulation profile
Adrenal	Adrenal hemorrhage	Abdominal US, CT & MRI
Metabolic	↓↓ Glucose, ↓↓ Ca, ↓↓ Na Acidosis, SIADH	Glucose, electrolytes, lactate, blood gases
Skin	SC fat necrosis	

Management

A) **Antepartum Management** (as before) Antepartum assessment of fetal well being

B) **Intrapartum Management** (as before) Intrapartum assessment of fetal well being

C) **Postpartum Management**

1. Correction of **hypoxia** (O_2 therapy, ventilation)
2. Moderation of CO_2
   a. Hypercapnia ⟶ Cerebral VD (Hge)
   b. Hypocapnia ⟶ Cerebral VC (Ischemia)
3. Moderation of **BP** (loss of cerebral autoregulation) "mean BP = 45-50 mmHg"
   a. ↓↓ BP ⟶ ↓↓ perfusion (Ischemia). Use inotropes to ↑↑ perfusion
   b. ↑↑ BP ⟶ Cerebral Hge
4. Correction of **metabolic** disturbances (↓↓ Glucose, ↓↓ Ca, ↓↓ Na)
5. Control of **seizures**: phenobarbitone, phenytoin…
6. Rx of **brain edema**: fluid restriction, dexamethasone, hyperventilation
7. **Cooling**: whole body or head cooling (↓↓ energy loss, ↓↓ glutamate release, ↓↓ apoptosis)
8. **Cerebroprotective** drugs (intervention)
   a. Selective head hypothermia
   b. Ca channel blockers
   c. Antagonists of excitatory aminoacid neurotransmitters receptors
   d. Free-radical scavengers: Allopurinol & Vitamin E
   e. VD: Prostacyclin
   f. Dexamethasone (↑↑ protein synthesis)
   g. Cyclooxygenase inhibitors (Indomethacin)
   h. Benzodiazepine receptor stimulation (Midazolam)
9. Management of **cardiac** effects of asphyxia
   a. Correction of hypocalcemia & hypoglycemia
   b. Avoid volume overload
   c. Inotropes: Dobutamine & Dopamine
10. Management of **renal** effects of asphyxia
    a. Monitor urine output
    b. Avoid nephrotoxic drugs
    c. Dopamine (renal dose)
11. Management of **GIT** effects of asphyxia
    a. Exclude NEC (Occult blood in stools)
    b. Avoid early feeding
12. Management of **Hematologic** effects of asphyxia (DIC)
    a. Transfusion: blood, plasma & platelets
13. Management of **pulmonary** effects of asphyxia
    a. Oxygenation & ventilation (M. ventilation, ECMO…)
    b. Management of PPHN

Seizures in the 1st 24 hr
- ☒ HIE
- ☒ IVH
- ☒ Pyridoxine deficiency
- ☒ Maternal LA
- ☒ Maternal hypotonic IVF
- ☒ Birth injury
- ☒ Neonatal sepsis

Causes of neonatal coma/dep.:
1. Causes of low Apgar
2. Metabolic (↓↓ G, ↓↓ Ca, ↑↑ Na, ↓↓ Mg, ↑↑ Mg)
3. Infection

Prognosis

- ☒ Death: 20%
- ☒ Neurological abnormalities (CP, MR…): 30%

Markers of Poor Prognosis

- Low Apgar at 20 min
- No spontaneous respiration at 20 min
- Sarnat 3
- Early-onset seizures
- Difficult seizure control
- Persistent oliguria (1st 36 hr)
- Persistent neurologic signs at 2 weeks
- ↑↑ Intracranial pressure > 10 mmHg
- ↑↑ Creatine kinase (CK-BB)
- aEEG & MRI picture

Respiratory System

Causes of First breath
- ↓↓ PaO_2
- ↑↑ $PaCO_2$
- ↓↓ Body temperature
- Redistribution of CO

Transition to Pulmonary Respiration

Requirements:

a. Patent airways
b. Mature RC
c. Removal of fetal lung fluid
- ☒ Before birth: Catecholamines, steroids
- ☒ Vaginal delivery: Intermittent chest compression
- ☒ After birth: Pulmonary veins & lymphatics

d. Creation of functional residual capacity (FRC): "surfactant"

Periodic breathing:
- Breathing for 10-15 sec at a rate of 50-60/min followed by:
- Apneic pause (5-10 sec)

Breathing Patterns

- Regular rhythmic respiration: in full-term neonates
- Periodic breathing: in full-term (during sleep) & Preterm neonates

- Periodic breathing returns to regular breathing by physical stimulation & Oxygenation
- Periodic breathing returns to regular breathing by 36 wk post-conceptional age
- Excellent prognosis

Apnea

Definition

Apnea is cessation of breathing for ≥ 20 seconds or any duration if associated with bradycardia & cyanosis

Apnea + Tachycardia = Seizure

Incidence *(of idiopathic apnea of prematurity)*

25% of preterm neonates < 34 wk (1.800 gm)
The majority of preterm neonates < 30 wk

Etiology

A) idiopathic apnea of prematurity (D_2-D_7)

1. Central
- Developmental immaturity of the respiratory center → Poor function / Paradoxical response to hypoxia
- No chest wall movement + No airflow

2. Obstructive
- Upper airway obstruction due to → Passive neck flexion / Pharyngeal instability
- Chest wall movement + No airflow

3. Mixed (50%)

B) Symptomatic apnea (*See table*)

Monitoring

Indications:

a. Preterm neonates < 34 wk (1.800 gm) for at least 1 wk
b. All neonates with serious diseases (symptomatic apnea)

Method: Monitors with apnea alarm

Symptomatic Apnea

System	Disease	Clinical Picture	Investigation
CNS	HIE ICH Seizures N/M disorders Anesthesia & sedation	DCL Bulging anterior fontanel Hypertonia/hypotonia Drug history	▪ Cranial US ▪ CT, MRI, MRS ▪ EEG &Amplitude EEG (aEEG) ▪ Toxicology screen
Respiratory	RDS Pneumonia Pneumothorax Obstructive airways	RD (4 grades)	▪ CXR ▪ Blood gases
CVS	Heart failure PDA Anemia BP	Tachycardia Murmur	▪ CXR ▪ ECG ▪ Echocardiography
GIT	Oral feeding GERD NEC Perforation	Feeding difficulties Abdominal distension Signs of feeding intolerance	▪ Occult blood in stools ▪ Erect abdomen X-ray ▪ Barium studies ▪ Continuous esophageal pH monitoring
Metabolic	Hypoglycemia Hypocalcemia ↓↓ Na & ↑↑ Na Hypothermia & hyperthermia Hyperammonemia Inborn errors of metabolism	Jitteriness Irritability Seizures Acidosis HSM	▪ Glucose ▪ Electrolytes (Na, K, Ca, Mg) ▪ NH3 ▪ Blood gases (metabolic diseases)
Infection	Sepsis Meningitis	Poor reflexes Poor feeding	▪ Sepsis screen (CBC, CRP, Cultures…) ▪ CSF
Idiopathic	Immaturity of the RC	Preterm neonate	▪ Exclusion

Management

1. Check position (obstructive apnea) & repositioning?
2. Tactile stimulation & gentle pharyngeal suctioning
3. Oxygenation (supplemental O_2 or bag & mask)
4. Rx of the cause (symptomatic apnea)
5. Avoid oral feeding
6. Packed RBC (if Hct < 25%)
7. Drug therapy
8. Assisted mechanical ventilation
   a. Continuous positive airway pressure (CPAP): Splinting of the airways
   b. Intermittent mandatory ventilation
   c. Controlled mechanical ventilation prolonged apnea

Drug	Dose	Action	Side Effects	Duration
Theophylline	Loading: 6 mg/Kg/dose Maintenance: 2-4 mg/Kg/dose Route: IV or oral every 6-12 hr	• ↑↑ RC • ↑↑ Diaphragmatic Contractility	• Tachycardia • Irritability • Convulsions	• 36 wk PCA • Control of apnea for 1 wk
Caffeine citrate	Loading: 20 mg/Kg/dose Maintenance: 5 mg/Kg/dose Route: IV or oral every 24 hr	↑↑ RC	• Less toxic	

Prognosis

A) idiopathic apnea of prematurity: Usually resolves by 36 wk post-conceptional age
B) Symptomatic apnea: Depends on the etiology

Transient Tachypnea of the Newborn

Definition

TTN is the most common cause of RD in term neonates

TTN is the most common cause of RD in term NB

Etiology

Delayed absorption of fetal lung fluid

Clinical Picture

- Early onset of respiratory distress (4 grades?)
- Chest examination is usually normal

Investigations

- CXR: Prominent vascular markings
  Inter-lobar fissure edema
- Arterial blood gases

Course

Rapid recovery within 3 days

DD

Other causes of RD (RDS, MAS, pneumonia…)

Treatment

No role of diuretic therapy!!

1. Supplemental O_2 (Nasal prongs, head box or incubator O_2)
2. CPAP may be needed
3. Parenteral or gavage feeding (to avoid aspiration)
4. Antibiotics *(It is not easy to exclude pneumonia)*

Respiratory Distress Syndrome

Incidence

60-80% of preterm neonates < 28 wk
20-30% of preterm neonates 32-36 wk
5% of term neonates

Risk Factors

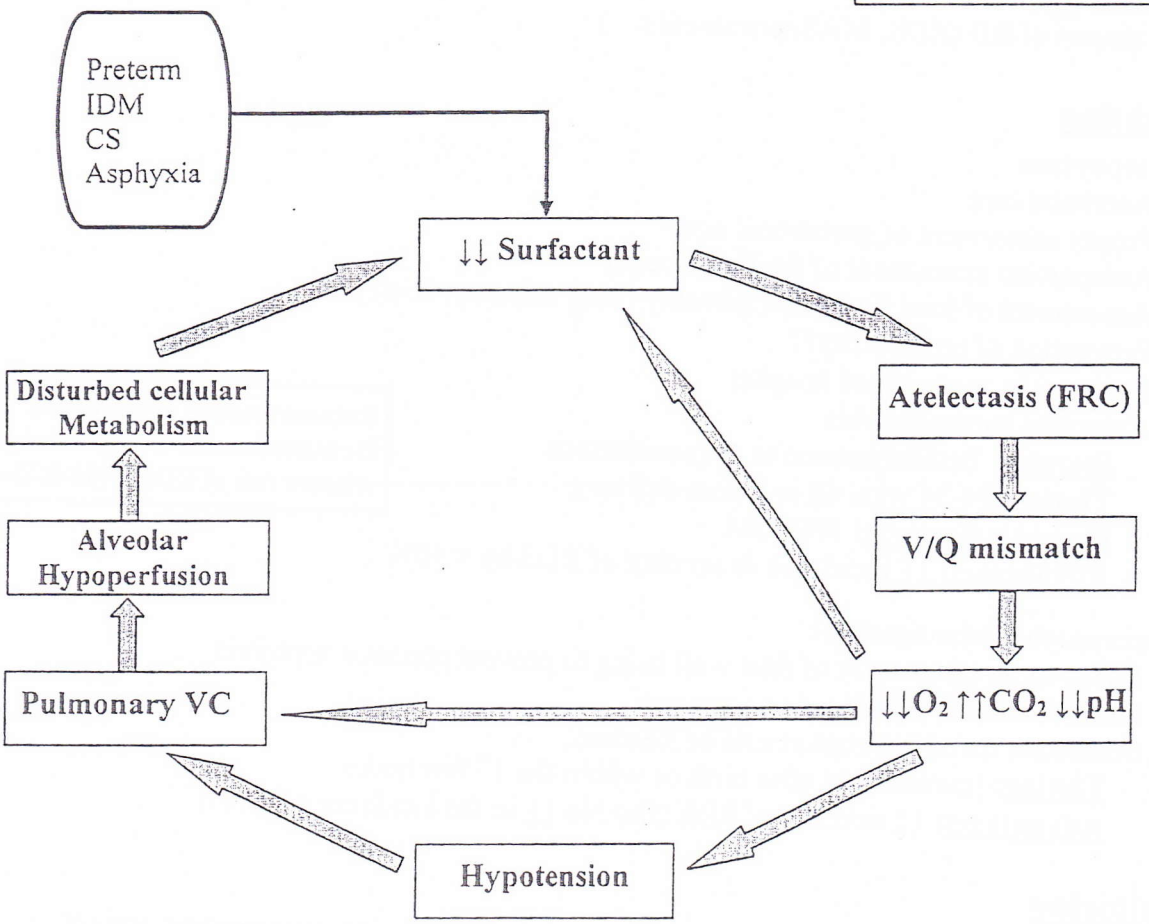
Risk is ↑↑ with	Risk is ↓↓ with
• Prematurity	• PIH
• IDM	• Chronic HTN
• CS	• Prolonged ROM
• Asphyxia	• Heroin
• Male sex & 2nd born twin	• Antenatal steroids

Pathophysiology *(Surfactant Deficiency)*

Surfactant

- **Production:** Alveolar cell type II
- **Maturation:** 35 wks of gestation (L/S ratio??)
- **Function:** ↓↓ Surface tension of the fluid lining the alveoli
- **Constituents:**

Main Constituents of surfactant:
1. Phosphatidyl choline (lecithin)
2. Phosphatidyl glycerol
3. Surfactant proteins (SP-A, B, C, D)
4. Cholesterol



Pathology

a. Gross: Deep purple (liver-like)
b. Microscopic: alveoli are lined with acidophilic hyaline membrane

Grades of RD:
1. Tachypnea
2. Retraction & working ala nasi
3. Grunting (forced expiration against closed glottis)
4. Cyanosis

Clinical Picture

- **Onset:** minutes* to hours
- **Course:** progressive worsening (over 24-72 hr) with gradual improvement in mild cases
- Respiratory distress (4 grades?)
- Chest examination: ↓↓ air entry, bronchial breathing, crepitations & wheezes

Investigations

- CXR: Reticulo-granular pattern
  Ground-glass appearance
  White lung
  Air bronchogram
- Arterial blood gases: ↓↓ O_2 ↑↑ CO_2 ↓↓ pH
- Blood glucose, electrolytes & CBC
- Antenatal prediction
- Postnatal examination of tracheal aspirate

DD

Other causes of RD (RDS, MAS, pneumonia…)

Prevention

A) Antepartum

- Antenatal care
- Proper assessment of gestational age
- Antepartum assessment of fetal well being
- Assessment of fetal functional maturity (lung maturity, how?)
- Prevention of prematurity??
- Delivery in an equipped hospital
- Antenatal corticosteroids
  Steroids: Betamethasone or dexamethasone
  Timing: 24-34 wks, 48 hr before delivery
  Contraindications: PIH, DM
  Advantages: ↓↓ incidence & severity of RDS by ≈ 40%

Betamethasone is preferred.
Dexamethasone is associated with relative risk of RDS, IVH & Death

B) Intrapartum Management

- Intrapartum assessment of fetal well being to prevent perinatal asphyxia
- Resuscitation & Stabilization
- Surfactant therapy (Prophylactic or Rescue)
  Timing: Immediately after birth or within the 1st few hours
  Advantages: ↓↓ severity of RDS (But No ↓↓ in the incidence of BPD)

Monitoring

a. Clinical: Vital signs, RD, work of breathing, peripheral perfusion, urine output, weight
b. Laboratory: ABG, electrolytes, blood glucose, Hct

Management

1. **Incubator care of LBW** (Temperature control, observation...)

> ▪ Avoid hypovolemia
> ▪ Avoid ↑↑ fluids (PDA, BPD)

2. **Nutrition**
   - **a. Parenteral:** IVF should be started on D_1, TPN is used in prolonged cases
   - **b. Enteral:** Trophic feeding is started once the neonate is stable
3. **Circulation:** Vascular access
   Volume expanders, +ve inotropes & pressors (dopamine)
4. **Antibiotics** *(It is not easy to exclude pneumonia)*
5. **Correction of acidosis:** Metabolic ⟶ $NaHCO_3$ (How?)
   Respiratory ⟶ Ventilation
6. **Respiratory support (Oxygenation & Ventilation)**

Targets:

- ☒ PaO_2 = 50-70 mmHg
- ☒ $PaCO_2$ = 45-55 mmHg
- ☒ O_2 % = 85-95%
- ☒ pH = 7.25-7.35

> Capillary blood samples are unreliable in assessment of PaO_2 but may be useful in $PaCO_2$ & pH

Monitoring: Pulse oximetry & ABG ⟹

> Injury from both hypoxia & hyperoxia should be balanced

Methods:

- a. Supplemental oxygen ≥ 60%
- b. Nasal CPAP [Pressure = 4-10 cm H_2O & FiO_2 = 60-100%]
- c. Mechanical ventilation: is indicated in
  - ▪ Failure of CPAP
  - ▪ pH < 7.2
  - ▪ PaO_2 < 50 mmHg
  - ▪ $PaCO_2$ ≥ 60 mmHg
  - ▪ Persistent apnea
  - ▪ ↑↑ Work of breathing
- d. High-frequency ventilation

Stepwise approach: ⟹

> Supplemental oxygen (≥ 60%)
> ↓
> If still PaO_2 < 50 mmHg
> ↓
> **Nasal CPAP**
> ↓
> If still PaO_2 < 50 mmHg
> ↓
> **Mechanical ventilation**

7. **Surfactant therapy**

☒ **Route:** Endotracheal (in 4 positions)

☒ **Types:**

- ▪ **Natural:**
  Bovine (Survanta)
  Porcine (Curosurf)
  Calf (Infasurf)
- ▪ **Synthetic** (Exosurf)

> **Initial ventilatory settings in RDS:**
> 1. **FiO_2:** Minimum for adequate oxygenation
> 2. **PIP:** 20-25 cm H_2O
> 3. **PEEP:** 4-6 cm H_2O
> 4. **Rate:** 20-60/min
> 5. **IT:** 0.4-0.6 sec
> 6. **Flow:** 2 L/Kg/min

☒ **Strategies:**

- ▪ **Prophylactic:** for prevention of RDS *"more effective"*
- ▪ **Rescue:** for established RDS

☒ **Complications:**

- ▪ Transient hypoxia & bradycardia
- ▪ ETT obstruction
- ▪ Pulmonary hemorrhage

8. **Inhaled Nitric Oxide (iNO)**

> • Nitric oxide is an endogenous vasodilator
> • It is used in infants with respiratory failure with or without PPHN
> • Inhaled NO cause selective pulmonary VD
> • iNO ↓↓ PVR & ↑↑ oxygenation

9. ECMO *(See later)*

Complications

1. Complications of ETT??

2. Complications of umbilical artery catheterization

- Thrombosis, embolism
- Hemorrhage
- Infection
- Reflex arterial vasospasm (leg blanching ± gangrene)
  - **Rx:** Immediate catheter removal
    - Warm the leg
    - Topical nitroglycerin
    - Intra-arterial tolazoline (1 mg)
- Renovascular hypertension

3. Complications of umbilical vein catheterization

- As umbilical artery
- Portal hypertension

4. Complication of hyperoxia

- Retinopathy
- Bronchopulmonary dysplasia

5. Air leak

- Pnumothorax
- Pneumomediastinum
- Pneumoperitonium
- Pneumopericardium
- Pulmonary interstitial emphysema
- SC emphysema
- Air Embolism

6. Anemia

- Frequent sampling
- VA related complications

7. PDA

C/P:

Apnea
Hyperdynamic circulation (Big pulse volume)
Murmur
Heart failure
Hepatomegaly

Investigations:

Rx:

- Adequate oxygenation
- Fluid restriction
- Indomethacin (or ibuprofen; 10-5-5)
- Surgical ligation

8. BPD

Cause of ↑↑ incidence of PDA:
1. Prematurity
2. Pulmonary hypertension
3. Systemic hypotension
4. Hypoxia
5. Acidosis

Lt to Rt shunt ↑↑ after resolution of RDS. Why?

Indomethacin in Rx of PDA
Dose: 0.2 mg/Kg every 12-24 hr
Freq.: 3 doses
Mechanism: ↓↓ PGs
CI: Bleeding
Thrombocytopenia < 50.000
NEC
Oliguria

Prognosis

A) **Mortality is ↓↓** by antenatal steroids, postnatal surfactant, NICU care
B) **Mortality is ↑↑** with ↓↓ GA
C) **Complications**

Neonatal Respiratory Distress & Failure

A) Respiratory Causes [RD (4 grades)]

a. Airways

- Nose: Choanal atresia
- Mouth: Pierre-Robin syndrome
- Tongue: Macroglossia
- Neck: Goiter & cystic hygroma
- Larynx: Web, cord paralysis, subglottic stenosis & laryngomalacia
- Trachea: Stenosis & laryngotracheomalacia

b. Lung parenchyma

- RDS, MAS, TTN, BPD, PPHN
- Pneumonia
- Congenital diaphragmatic hernia
- Congenital lobar emphysema
- Air leak (pneumothorax, mediastinum…)
- Lung hypoplasia (1^{ry} or 2^{ry})

B) Neurological Causes [Shallow, Irregular, Gasping, Apnea, cyanosis]

a. CNS

- Maternal drugs
- HIE, ICH
- Congenital malformation
- Apnea

b. N/M apparatus

- N/M diseases (Congenital myopathy, Myotonic dystrophy, SMA type 1)

C) Cardiac Causes

- Heart failure
- PPHN

D) Hematological Causes

- Anemia
- Polycythemia

E) Metabolic Causes

- Hypoglycemia
- Hypothermia
- Acidosis

Extrapulmonary Extravasation of Air (Air Leak)

Definition It is air extravasation outside the lungs

Type	Site of air leak	Clinical picture	Investigation
Pneumothorax	Pleural space		X-ray
Pulmonary interstitial emphysema	Pulmonary interstitium	RD, gradual deterioration on M. ventilation	
Pneumomediastinum	Mediastinum	Hypotension, Distant heart sounds, Congested neck veins	
Pneumopericardium	Pericardium	Hypotension, Distant heart sounds	
Pneumoperitoneum	Peritoneum	Usually asymptomatic	
SC emphysema	SC tissue	Crepitus	
Air Embolism	Systemic circulation	Fatal if large amount	

Respiratory Support

Forms

1. **Supplemental Oxygen** [prongs, box, incubator O_2]
2. **CPAP** (Continuous positive airway pressure)
3. **Positive pressure ventilation**
4. **High frequency ventilation**

} **Mechanical Ventilation**

5. **NO** (Nitric oxide)
6. **ECMO** (Extracorporeal membrane oxygenation)

Mechanical Ventilation

Introduction

Human hand is the best ventilator, but because of human fatigue, mechanical ventilators were invented *(all ventilators are blind)*

Classification

Ventilators
(Lung Inflation)

- **Negative pressure Ventilators**
  - Physiologic & Noninvasive
  - Difficult observation & nursing
- **Positive pressure Ventilators**
  - **Conventional** (Rate ≤ 60/min)
    - According to mechanism of cycling (termination of inspiration)
      - **Time-cycled*** (after a fixed time)
        - The most commonly used ventilators are **Time-cycled, pressure-limited**
      - **Pressure-cycled** (after a selected P)
        - Inspiration is terminated regardless the TV
        - •Condition of ↑↑ airway P → No adequate TV
        - •Condition of ↓↓ airway P (leak in tubes) → No stop of inspiration → Pneumothorax
      - **Volume-cycled** (after a selected tidal volume)
        - Inspiration is terminated regardless the P
        - •TV of infants is small (lost in the tubing system)
        - •Condition of ↓↓compliance → air will be compressed → ↓↓ actual TV
  - **High Frequency** (Rate = 60-3600)
    - H.F. oscillators (HFO)
    - H.F. flow interrupter (HFFI)
    - H.F. jet ventilator (HFJ)

Ventilator System

1. Oxygen source
2. Compressed air source
3. Mixer → variable O_2 concentration (FiO_2)
4. Ventilator → ventilatory support
   - → Constant = CPAP
   - → Intermittent = IMV or CMV
   - → Combined = PEEP + IMV or CMV
5. Humidifier
6. Patient breathing circuit

Ventilatory Support & Ventilatory Settings

	CPAP (Continuous positive airway pressure)	IMV (Intermittent Mandatory ventilation)	CMV (Controlled Mechanical ventilation)
Function (Action)	▪ Keep the airway pressure positive throughout the cycle ▪ Splinting of the airways ▪ ↑↑ FRC ▪ Prevention of atelectasis ▪ ↓↓ work of breathing	▪ Partial intermittent support ▪ Only some breaths are given ▪ These breaths may be triggered by the patient own inspiration (SIMV) ▪ ↓↓ work of breathing	▪ Total intermittent support ▪ Usually combined with PEEP
Patient's Breathing	Spontaneous	Spontaneous	Absent or ineffective
Indications	▪ ↓↓ Oxygenation (in spite of supplemental O_2) ▪ Mild RDS ▪ Moderately frequent apnea ▪ Weaning from M. Ventilation ▪ ↑↑ work of breathing	▪ Failure of CPAP to ↑↑ oxygenation & ↓↓ work of breathing (Pa O_2 < 50) ▪ $PaCO_2 \geq 60$ mmHg (Hypoventilation) ▪ pH < 7.2 ▪ Shock ▪ Coma	▪ Persistent apnea ▪ Type II respiratory failure ▪ Failure of CPAP & IMV ▪ pH < 7.2 ▪ PaO_2 < 50 mmHg ▪ $PaCO_2 \geq 60$ mmHg
Methods	Nasal, Nasopharyngeal or ETT	ETT	ETT
Ventilatory settings	▪ FiO_2 = 40-100% ▪ Pressure = 4-10 cm H_2O	FiO_2, Rate, Inspiratory time (IT), Expiratory time, I/E ratio, Flow, Tidal volume, Peak inspiratory pressure (PIP), Positive end expiratory pressure (PEEP)	
Assessment	Oxygenation & work of breathing	Oxygenation, ventilation & work of breathing	Oxygenation & ventilation
Complications	▪ Gastric distension (insert gastric tube) ▪ Nasal septal injury ▪ Feeding difficulties ▪ Air leak (pneumothorax) ▪ ↑↑ Intrathoracic P ⟶ ↓↓ VR, ↓↓ BP, ICH	Complications of Mechanical Ventilation	

Settings to improve Oxygenation
- ↑↑ **FiO_2**
- ↑↑ **PEEP**

Settings to improve Ventilation
- ↑↑ **Rate**
- ↑↑ **PIP**
- ↑↑ **Tidal volume [TV = Flow x IT]**

Assessment of Oxygenation
- Color: Pink
- PaO_2
- O_2 Saturation

Assessment of Ventilation
- Chest expansion
- Air entry
- $PaCO_2$

Complications of Mechanical Ventilation

	Complication	How to avoid
ETT	▪ Injury (oral cavity, nose, vocal cord, larynx) ▪ Obstruction ▪ Malposition ▪ Infection	▪ Careful intubation ▪ Suction ▪ Proper fixation (check position) ▪ Aseptic precautions
Ventilator	▪ Power failure ▪ Disconnection ▪ Kinking ▪ Humidifier water loss	Check
Settings	▪ ↑↑ Pressure (PIP or PEEP) ⟶ air leak ▪ ↑↑ PEEP ⟶ ↓↓ VR ⟶ ↓↓ CO + ↑↑ ICP ▪ ↑↑ Inspiratory time ▪ ↓↓ Expiratory time	Avoid high or inappropriate settings
Patient	▪ Fighting ▪ Self extubation ▪ Feeding ▪ Underlying pathology	▪ Sedation (Fentanyl, midazolam...) ▪ Muscle paralysis (pancuronium) ▪ Parenteral nutrition ▪ Adjust settings according to pathology

Causes of deterioration of blood gases

A) Sudden

1. ETT: displacement or obstruction
2. Ventilator: power failure
3. Low pressure
4. Circuit: Disconnection or leak
5. Air leak (pneumothorax...)
6. Massive lung collapse
7. Cardiac compromise (↓↓ VR)
8. CNS: ICH

B) Gradual

1. ETT: partial obstruction
2. Partial lung collapse (more on the Rt side)
3. Lack of physiotherapy
4. Infection
5. Anemia
6. PDA
7. BPD
8. Fighting

Mechanical ventilation in specific diseases

A) ↓↓ Compliance (RDS & pneumonia)

- ↑↑ Inspiratory time (I/E = 1:2 or even 1:1)
- ↑↑ PEEP

B) ↑↑ Airway pressure (MAS & asthma)

- ↑↑ Expiratory time (I/E = 1:3 or even 1:4)
- ↓↓ PEEP ≤ 4 cm H_2O

C) Air leak (pneumothorax)

- ↑↑ FiO_2 & ↓↓ PIP, PEEP
- HFV

Causes of Air leak (pneumothorax)

1. ↑↑ Pressure (PIP or PEEP)
2. ↑↑ IT
3. ↓↓ Expiratory time
4. ETT malposition (usually into Rt lung)
5. Improved lung pathology without ↓↓ settings
6. Unilateral lung pathology
7. Inadequate humidification
8. Aggressive physiotherapy

High Frequency Ventilators

Description

Extremely rapid rates with small tidal volumes (< dead space)

Types

HFO, HFJ, HFFI

Advantages

a. ↓↓ Barotrauma (lung injury)
b. Recruitment of collapsed alveoli
c. Useful in air leak (pneumothorax...)

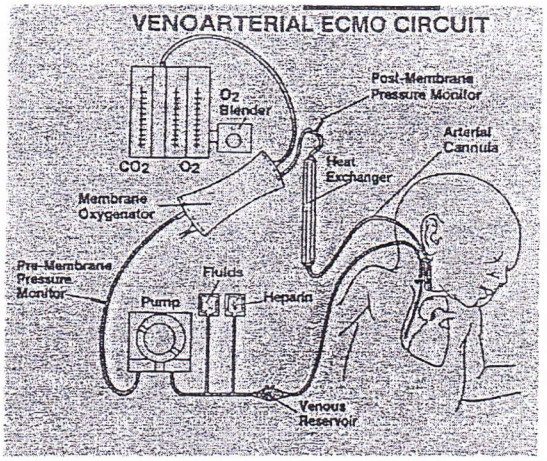
Disadvantages

a. Complex & expensive
b. No statistically significant difference in outcome

Extracorporeal membrane oxygenation
ECMO

Definition

It is a form of cardiopulmonary bypass that augments systemic perfusion & provides gas exchange; so allows lung to recover *"lung rest"*



Indications (Severe cardiorespiratory failure)

1. PPHN
2. MAS
3. RDS
4. Congenital diaphragmatic hernia
5. Heart disease
6. Sepsis

Technique

- Two VA (IJV & Carotid artery)
- Venous blood is drained from the IJV, pumped through a membrane oxygenator "artificial lung" which extracts CO_2 & adds O_2
- The blood is then returned to the baby through an artery
- The lungs is still mechanically ventilated but at a low settings ()

Complications

- Bleeding (heparin): IVH...
- Thrombosis & embolism
- Thrombocytopenia
- Infection
- Ischemic brain injury (due ligation of carotid artery)

Inhaled Nitric Oxide

☒ Nitric oxide is an **endogenous vasodilator**
☒ Used in infants with **respiratory failure with or without PPHN**
☒ **Inhaled NO** cause selective pulmonary VD
☒ NO lowers pulmonary vascular resistance & ↑↑ oxygenation

Bronchopulmonary Dysplasia

Definition

BPD is **lung injury** in neonates requiring mechanical ventilation & supplemental O_2 for Rx of respiratory failure (RDS*)

Incidence *(Variable according to definition used)*

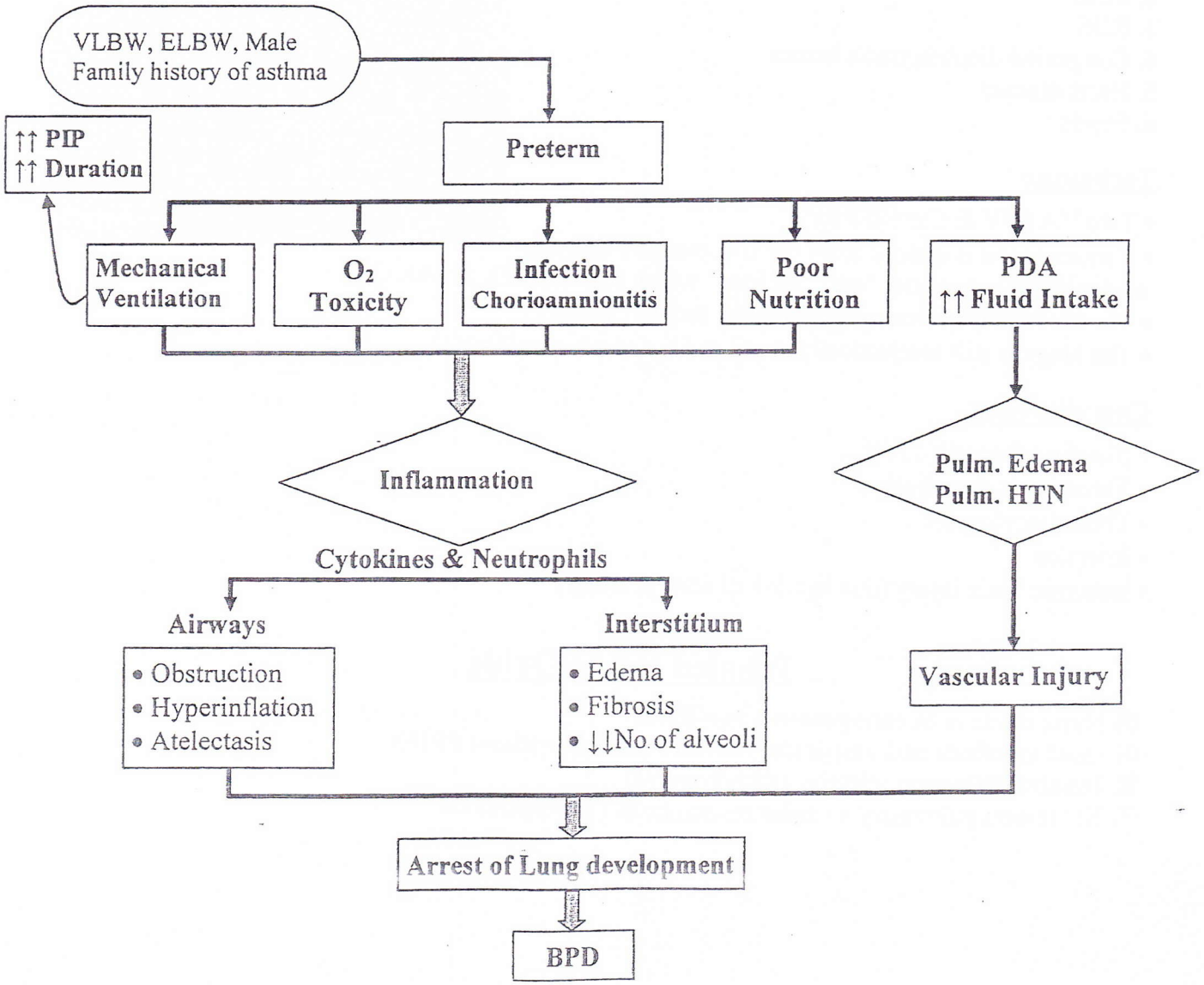
The most susceptible group is neonates < 1.250 gm
It is relatively uncommon in neonates > 32wk

The term **BPD** should be used rather than chronic lung disease (**CLD**)

Diagnostic Criteria

		< 32 wk	≥ 32 wk
Time of assessment		• 36 wk PMA • Discharge	• 56 days • Discharge
Essential criterion		Rx with > 21% O_2 for ≥ 28 days PLUS	
At Time of assessment	**Mild BPD**	Breathing room air	
	Moderate BPD	Needs < 30% O_2	
	Severe BPD	Needs ≥ 30% O_2 or PPV	

Pathophysiology (= risk-factors + pathogenesis)



Pathology

a. Acute phase: edema, cellular infiltration & release of cytokines
b. Chronic phase: fibrosis & obliterative bronchiolitis

Clinical Picture

- Respiratory distress (4 grades?)
- Prolonged mechanical ventilation & O_2 therapy "O_2 dependence"
- Heart failure
- Chest examination: wheezes & crepitations

Investigations

- Arterial blood gases: hypoxia, hypercapnia & acidosis
- CXR: Early ⟶ RDS
  Then ⟶ areas of atelectasis, hyperinflation & cyst formation
- Echocardiography: PDA, pulmonary HTN & Rt ventricular hypertrophy

Prevention

1. Antenatal steroid therapy (Betamethasone)
2. Postnatal surfactant therapy (prophylactic therapy is more effective)
3. Vitamin A"↑↑ epithelial repair" (5.000 IU, IM, 3 times/week)
4. Rx of PDA
5. Avoid excess IVF
6. Ventilatory settings (avoid high PIP)
7. High-frequency ventilation

Monitoring

a. Clinical: vital signs, RD, work of breathing, peripheral perfusion, urine output, weight
b. Laboratory: ABG, electrolytes, blood glucose, Hct

Treatment

1. Nutrition
- ↑↑ Caloric intake
- Supplementation with Vitamin A & vitamin E "anti-oxidant"
- Trace elements (Se, Zn, Cu)

2. Fluid restriction

3. Diuretic therapy
- Furosemide or hydrochlorothiazide ± spironolactone

4. Dexamethasone *"Anti-inflammatory"*
- Short course of low dose (0.25 mg/Kg/day for 5-7 days)
- ↓↓ O_2 requirements,↓↓ ventilatory settings, facilitates extubation & ↓↓ post-extubation laryngeal edema
- **Side effects:** HTN, hyperglycemia, GIT bleeding & perforation, sepsis & ↑↑ risk of CP

The routine use of dexamethasone is Not recommended

5. Bronchodilators: Inhaled β2 agonists

6. Respiratory support
- Chest physiotherapy & suctioning
- O_2 & mechanical ventilation to maintain satisfactory oxygenation

PaO_2 = 50-70 mmHg
$PaCO_2$ = 50-70 mmHg
pH > 7.3

7. Inhaled Nitric Oxide (iNO)

8. Blood transfusion

9. Rx of infection

10. Rx of PDA

Home Treatment

1. **Nutrition** (↑↑ Caloric intake)
2. **Diuretic therapy**
3. **Bronchodilators**
4. **Immunization**
   - Routine immunization
   - Pneumococcal vaccine
   - Influenza vaccine
   - Monoclonal Ab against RSV (Palivizumab)
5. **Avoid passive smoking**

Complications

1. Growth failure
2. Systemic HTN, pulmonary HTN, LV hypertrophy, RV hypertrophy
3. Airway hyperreactivity
4. Complications of medications:
   - ☒ Furosemide (Hypokalemia & nephrocalcinosis)
   - ☒ Dexamethasone?
   - ☒ Antibiotics
   - ☒ O_2: ROP

Prognosis

- Recovery within 6-12 months (in surviving neonates)
- Mortality 20% (respiratory failure, infection , cardiac complications)
- Complications

Aspiration of Foreign Material Syndrome

Etiology

1. MAS
2. Aspiration of milk or medications
   - Immaturity (uncoordinated reflexes)
   - Improper feeding
   - RD, TOF, GERD, CP

Clinical Picture

Chocking & aspiration pneumonia

Investigations

- CXR
- Bronchoscopy

Treatment

- Respiratory support
- Rx of pneumonia
- Bronchoscopy

Meconium Aspiration Syndrome

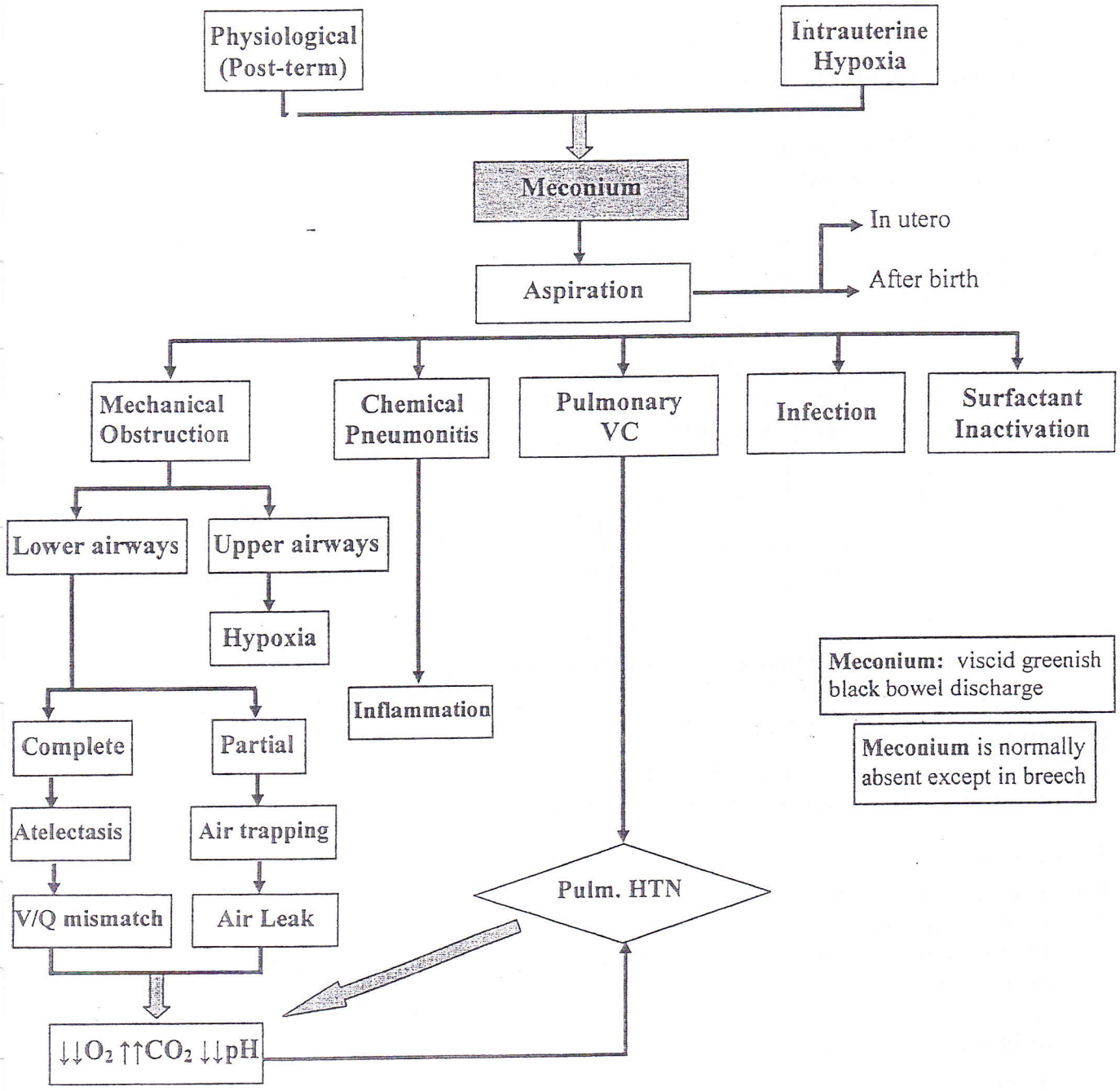
Definition

MAS is RD in a neonate borne through meconium-stained amniotic fluid (MSAF) whose symptoms can not be otherwise explained

Incidence

- MSAF occurs in 13% of all deliveries
- MAS occurs in 5% of MSAF

Pathophysiology



Clinical Picture

- Onset: within few hours
- MSAF
- Respiratory distress (4 grades?)
- Chest examination: ↓↓ air entry, bronchial breathing, crepitations & wheezes

Investigations

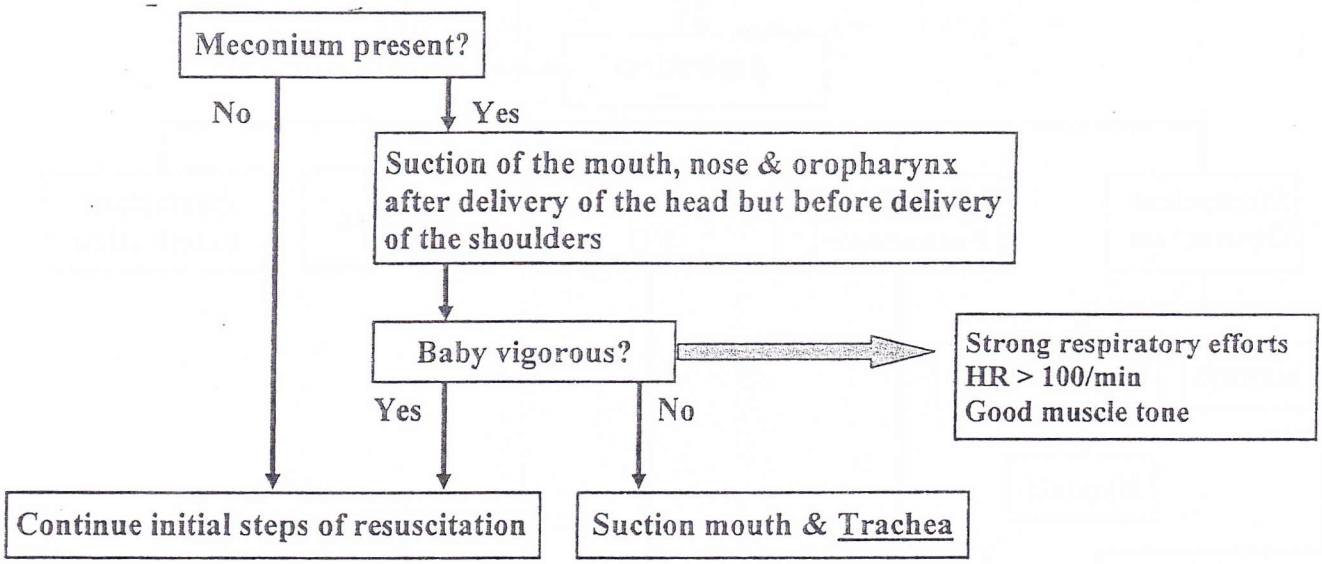
- CXR: Patchy infiltrates
  Hyperinflation (↑↑ AP diameter + Flat diaphragm)
  Air leak (pneumothorax)
- Arterial blood gases: ↓↓ O_2 ↑↑ CO_2 ↓↓ pH

DD Other causes of RD (RDS, pneumonia…)

Prevention

A) **Antepartum**
- Antenatal care
- Proper assessment of gestational age
- Antepartum assessment of fetal well being (placental insufficiency)
- Delivery in an equipped hospital

B) **Intrapartum Management**
- Intrapartum assessment of fetal well being
- Management of MSAF



Monitoring

a. Clinical: vital signs, RD, work of breathing, peripheral perfusion…
b. Laboratory: ABG, electrolytes, blood glucose, Hct

Treatment

1. **Incubator care** (Temperature control, observation...)
2. **Respiratory support**
   - Frequent chest physiotherapy & suctioning
   - Supplemental oxygen
   - Nasal CPAP
   - Mechanical ventilation

Mechanical ventilation is risky, but often required!

3. **Antibiotic**
4. **Rx of pulmonary hypertension**
5. **Rx of air leak**
6. **Surfactant therapy**
7. **Inhaled Nitric oxide**
8. **ECMO**

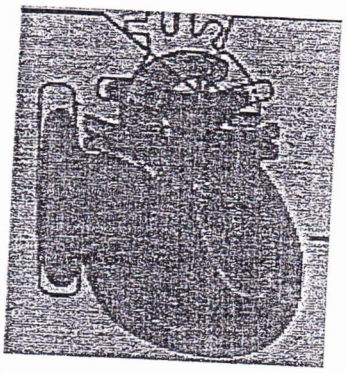
Persistent Pulmonary Hypertension of the NB

(Persistent Fetal Circulation - PPHN)

Definition

It is persistent elevation of the pulmonary vascular resistance after birth with Rt to Lt shunt across:

a. Patent foramen ovale
b. PDA



Incidence

- PPHN occurs in 1:1000 (more in **term & post-term**)
- Mortality = 50%

Etiology

A) Pulmonary VC

1. Perinatal asphyxia
2. Pulmonary parenchymal diseases: RDS, MAS, diaphragmatic hernia
3. CNS causes (Hypoventilation)
4. Sepsis
5. ↓↓ Ca, ↓↓ Glucose & acidosis

B) Pulmonary vascular smooth muscle hypertrophy: Chronic IU hypoxia

C) Myocardial depression

1. HIE
2. Myocarditis
3. Sepsis
4. Polycythemia
5. ↓↓ Ca, ↓↓ Glucose & acidosis

D) Sepsis (Why?)

E) ↓↓ Cross sectional area of pulmonary vascular bed

1. 1^{ry} pulmonary hypoplasia
2. 2^{ry} pulmonary hypoplasia (Potter's syndrome)
3. Congenital diaphragmatic hernia
4. Alveolar capillary dyplasia (Fatal)

F) Idiopathic

Pathology

- Pulmonary vasospasm
- Pulmonary hypoplasia
- Pulmonary vascular remodeling (↑↑ Medial thickness)

PPHN should be suspected in the presence of any risk factor

Clinical Picture

- Onset: within few hours
- Respiratory distress (4 grades?)
- Cyanosis
- Single accentuated S_2
- Pulse oximeter readings in the UL & LL??
- Hyperoxia test

Hyperoxia test

- 100% O_2 for 10 min (Head box)
- ABG (PaO_2) before & after O_2
- **If PaO_2 > 110 mmHg**
  CHD is unlikely
  Lung disease or PPHN
- **If PaO_2 < 110 mmHg**
  CHD is likely
  Severe lung disease or PPHN

DD Other causes of RD & cyanosis (RDS, pneumonia…) & CHD
[CHD: Cardiomegaly, murmur (grade 3), weak pulse, hyperoxia test…]

Investigations

- CXR: Minimal findings (normal lung fields + normal cardiac shadow)
- Arterial blood gases: ↓↓ O_2 ↑↑ CO_2 ↓↓ pH
- Echocardiography:
  - CHD, cardiac contractility, PDA
  - Direction of flow across PFO & PDA
  - Estimation of pulmonary pressure

Treatment

1. **Incubator care** (Temperature control, observation...)
2. **Respiratory support**
   - Supplemental oxygen (100% O_2)
   - Mechanical ventilation (if failure of 100% O_2)
   - HFV (if failure of conventional mechanical ventilation)
3. **Positive inotropic agents**
   - Dopamine
   - Dobutamine
4. **Correction of** ↓↓ Ca, ↓↓ Glucose, acidosis & polycythemia
5. **Tolazoline** (α receptor antagonist): pulmonary VD [Side effect = systemic hypotension]
6. **Sildenafil** *(Viagra)*
7. **Prostacyclin**
8. **Surfactant therapy**
9. **Inhaled Nitric oxide**
10. **ECMO**

PaO_2 = 80-100 mmHg
$PaCO_2$ = 35-45 mmHg
pH = 7.35-7.45

Prognosis

- Mortality ≈ 50%
- Related to the etiology (pulmonary hypoplasia, diaphragmatic hernia…)

Pneumothorax

Definition

It is the presence of air within the pleural space

Incidence

- Asymptomatic*: 1-2% of all newborn infants
- Symptomatic

Etiology

A) Spontaneous

B) Secondary

☒ Lung diseases

- RDS, MAS, BPD
- Lung cysts (congenital or acquired)
- Lung hypoplasia (1ry or 2ry)
- Congenital diaphragmatic hernia
- Congenital lobar emphysema
- Pneumatocele

☒ Traumatic

- Barotrauma (ambu-bag or mechanical ventilation). Risk factors
- Vigorous resuscitation or physiotherapy
- Vascular access insertion "pleural injury"
- Chest surgery
- Accidental trauma (penetration wounds)

Causes of Air leak (pneumothorax)

1. ↑↑ Pressure (PIP or PEEP)
2. ↑↑ IT
3. ↓↓ Expiratory time
4. ETT malposition (usually into Rt lung)
5. Improved lung pathology without ↓↓ settings
6. Unilateral lung pathology
7. Inadequate humidification
8. Aggressive physiotherapy

Lung Cysts

☒ Congenital

☒ Acquired*

C/P:

- Asymptomatic
- Rupture ⟶ Pneumothorax

Rx:

- Conservative
- Surgical removal

Clinical Picture

- Asymptomatic
- Respiratory distress (4 grades?)
- Chest examination:
  - Unilateral bulge
  - Mediastinal shift
  - Hyper-resonance
  - ↓↓ air entry
- May be bilateral in 10%
- Tension pneumothorax ⟶ Collapse of the ipsilateral lung
  Compression of the opposite lung
  ↓↓ VR, ↓↓ BP, Obstructive shock

Investigations

- CXR: Jet-black translucency + Mediastinal shift
- Needle aspiration (2^{nd} intercostals space MCL): "Diagnostic Therapeutic test"

Treatment

- Conservative management (if asymptomatic): Observation + 100 % O_2
- Needle aspiration
- Chest tube with underwater-seal drainage
- HFV is the ventilatory treatment of choice

Complications

- Respiratory failure
- Obstructive shock
- ICH (↑↑ Intra-thoracic pressure)
- SIADH

Surgical Emergencies in the NB

I. Fetal manifestation

1. **Polyhydramnios:** TOF, Intestinal obstruction, hydrocephalus
2. **Oligohydramnios:** Obstructive uropathy (PUV)…
3. **Dytocia:** Hydrops
4. **Fetal ascites:** Obstructive uropathy, hydrops, thoracic duct obstruction, CHD

II. Neonatal manifestation

1. **Respiratory distress**
   - ☒ Choanal atresia
   - ☒ TOF
   - ☒ Congenital lobar emphysema
   - ☒ Congenital diaphragmatic hernia

Intubate with ETT

2. **Scaphoid abdomen:** Congenital diaphragmatic hernia
3. **Abdominal distension**
   - ☒ Pneumoperitoneum (= perforated viscus; stomach, intestine…)
   - ☒ Intestinal obstruction

NGT is mandatory

   - Congenital IO
     - Duodenal atresia, annular pancreas, fibrous band of Ladd
     - Jejunal, ileal atresia
     - Malrotation, volvulus
     - Imperforate anus, Hirschsprung disease
   - Acquired IO
     - Functional "paralytic ileus": RDS, sepsis, NEC
     - Organic "mechanical": Intussusception, strangulated inguinal hernia, NEC
4. **Abdominal wall defects** (Omphalocele & gastroschisis)

	Omphalocele	Gastroschisis
Defect	Umbilicus	To the RT of the umbilicus
Relation to the cord	Inside the cord	To the RT of the cord
Coverings	Peritoneal membrane & amnion	No coverings
Diagnosis	Antenatal US screening	
Treatment	NGT + NPO + IVF *(TPN may be needed)* Wrapping with warm, sterile, saline soaked gauze(↓↓heat loss& protection) Surgical repair	

5. **Excessive salivation:** TOF
6. **Vomiting** *(see before)*
7. **Hematemesis & bloody stools**
   - ☒ NEC
   - ☒ Gastric stress ulcer
   - ☒ Swallowed maternal blood ⟹

Apt test:
Test done in GIT bleeding to detect maternal RBCs

Kleihauer test:
Test on maternal blood to detect fetal RBCs

8. **Abdominal mass**
9. **Inguinal hernia**
10. **Birth injury** (fractures, ICH, solid organ injury)
11. **Failure to pass meconium** (IO, imperforate anus)
12. **Failure to pass Urine** (Obstructive uropathy e.g., PUV)

Digestive System

Neonatal Vomiting

Etiology

A) Well-doing baby

1. Amniotic gastritis
2. Swallowed maternal blood
3. Feeding disorders
   - Wrong feeding & overfeeding,
   - Failure of eructation
   - ↑↑ Manipulation
4. GERD: following meals, related to posture
5. CHPS: Usually starts in the 2nd or 3rd week, projectile, shortly after meals, never bilious
   Pyloric mass may be palpated, diagnosed by US, barium meal
   More common in ♂
   Rx: pyloromyotomy (**Ramstedt's** operation)
6. Cow's milk protein allergy

B) Sick baby

1. Tracheoesophageal fistula (TOF) *(1st feed)*
2. Congenital intestinal obstruction (e.g., atresia…)
3. Acquired intestinal obstruction (e.g., Intussusception…)
4. Ileus (RDS, sepsis, NEC…)
5. ↑↑ Intracranial tension: HIE, ICH, meningitis
6. Inborn errors of metabolism:
   - Urea cycle defects
   - Organic academia
   - Galactosemia
   - CAH

VATER/VACTERL:
Vertebral, Anorectal, Cardiac, Trachea, Esophagus, Renal, Limb

Neonatal Constipation [Failure to pass stool for > 36 hrs]

1. **Since birth**
   - Causes of intestinal obstruction…
   - Meconium plug
   - Meconium ileus
   - Hirschsprung disease
2. **Not presenting at birth**
   - Hirschsprung disease
   - Hypothyroidism

Meconium plug:
Structure: Low water content
Risk factors: IDM, CF, $MgSO_4$
C/P: IO
Rx:
- Glycerin suppositories
- Enema (Saline or gastrographin)
- Surgical removal

Meconium ileus (CF):
C/P: IO, peritonitis
Rx:
- Glycerin suppositories
- Enema (Saline or gastrographin)
- Surgical

Meconium peritonitis:
Etiology: M. ileus or M. plug
C/P: IO, perforation
Rx: Surgical drainage

Neonatal Diarrhea *(GIT)*

Oral Candidosis

1. Maternal transmission: vaginal, breast
2. Prolonged antibiotics
3. T-cell dysfunction
4. HIV infection

Necrotizing Enterocolitis (NEC)

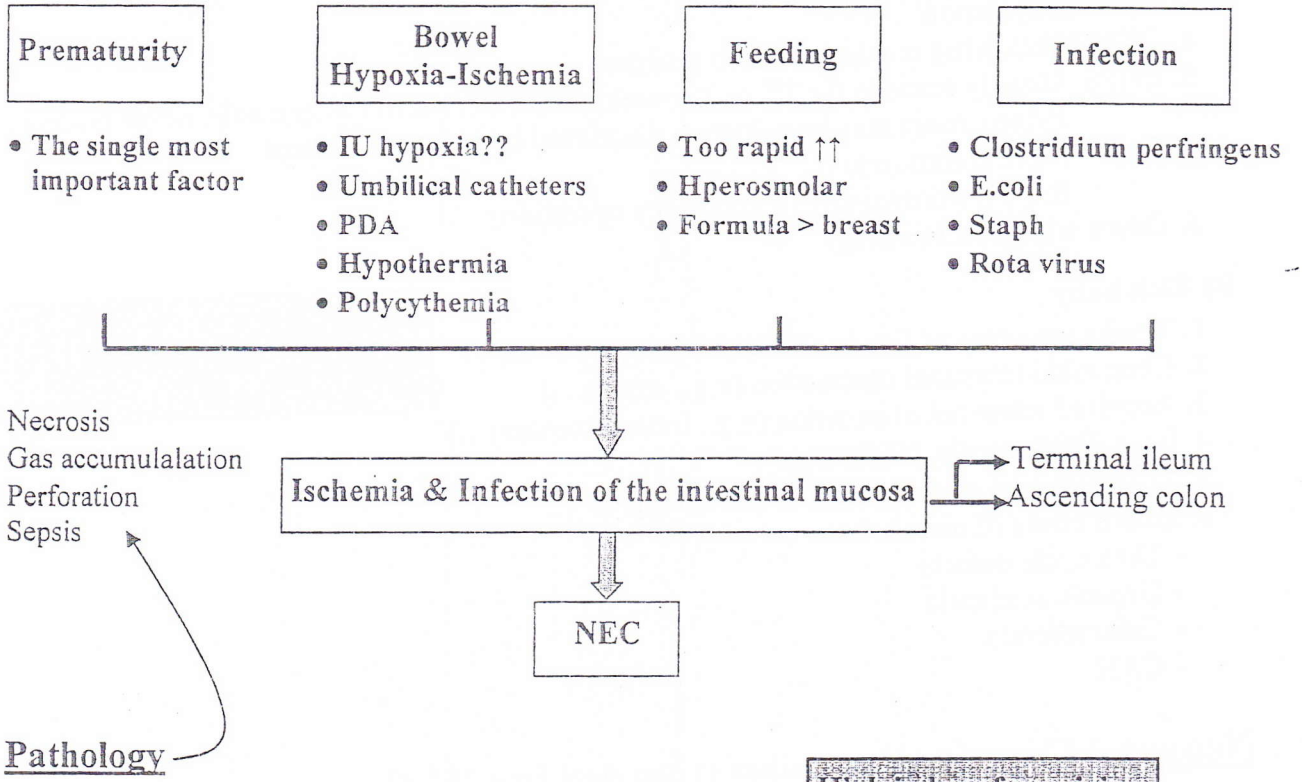
Definition

NEC is a syndrome of acute intestinal inflammation & necrosis

Incidence

The most susceptible group is neonates 30-32 wks
10% are full-term

Pathophysiology (= risk factors + pathogenesis)



High index of suspicion

Clinical Picture (Onset = 1-2 wks)

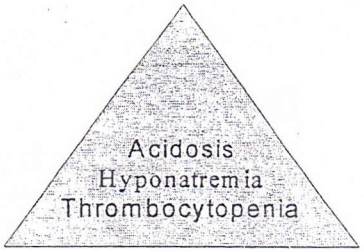
A) Systemic signs

- RD or apnea
- Temperature instability
- Hypotension, poor perfusion, shock
- Lethargy, poor feeding
- Bleeding tendency
- Acidosis

B) Local (Abdominal) signs

- Feeding intolerance?? →
  1. Bilious or bloody gastric residue
  2. ↑↑ Residue (>25% of the previous feed)
  3. ↑↑ Abdominal girth
  4. Vomiting
  5. **Bloody stools**
  6. Watery stools
- Abdominal distension & tenderness
- Signs of peritonitis/perforation
  - Abdominal distension
  - Abdominal wall edema
  - Abdominal wall discoloration
  - Absent intestinal sounds *"ileus"*
  - Ascites

Investigations



- CXR:
  - Dilatation of intestinal loops
  - Intestinal wall edema
  - Intramural air (**pneumatosis intestinalis**)
  - Pneumoperitoneum
  - Portal vein air
- Blood: Triad of metabolic acidosis, hyponatremia & thrombocytopenia
- Stool analysis: Gross or occult blood in stools

Bell Staging Criteria

Stage I = Clinical symptoms & signs
Stage II = Clinical symptoms & signs + pneumatosis intestinalis
Stage III = Clinical symptoms & signs + pneumatosis intestinalis + critically ill

Prevention

1. Prevention of prematurity
2. Antenatal steroid therapy (↓↓ incidence of NEC)
3. Use breast milk
4. Avoid hyperosmolar feeds
5. Avoid rapid ↑↑ in feed volume (not > 15-20 cc/Kg/day)
6. Prebiotics & probiotics (trials)

Monitoring

a. Clinical: vital signs, abdominal signs, RD, peripheral perfusion, urine output, weight
b. Laboratory: ABG, electrolytes, blood glucose, Hct, serial X-ray

Treatment

I. Medical treatment

1. Nutrition

- ☒ NPO & TPN
- ☒ Initiation of feeding (2-week bowel rest): Trophic feeding with breast milk
- ☒ Monitor signs of feeding intolerance

2. Supportive measures

- ☒ **Removal** of umbilical catheters
- ☒ **Respiratory**: Airway, Supplemental O_2 or mechanical ventilation may be needed
- ☒ **CVS**: Rx of shock, hypotension, Dopamine (2-5 µg/Kg/min): ↑↑ splanchnic blood flow
- ☒ **Metabolic**: correction of acidosis & electrolyte disturbances
- ☒ **Blood**: whole blood , platelet transfusion, vitamin K supplementation

3. Antibiotics *(broad-spectrum)*: Ampicillin + Gentamicin + Clindamycin
Adjust the antibiotics according to the results of cultures (blood, stool…)

II. Surgical

Indications:

- ☒ Intestinal perforation
- ☒ Failure of medical treatment

Options:

- ☒ Peritoneal drainage
- ☒ Resection-anastomosis

Complications

- Electrolyte disturbances, DIC, sepsis
- TPN
- Stricture & enteric fistula
- Short bowel syndrome (diarrhea & FTT)

Neonatal Jaundice

Definition

Neonatal jaundice is yellowish discoloration of the skin & mucous membrane
Clinical jaundice appears when bilirubin level is > 7 mg % *(In adults if > 2 mg %)*

Incidence

60% of full-term & 80% of preterm neonates develop jaundice in the 1st week of life
It may be caused by very mild or very serious condition that should be identified

Bile Pigments Metabolism

1. Production of bilirubin

- ☒ Old RBCs → Hemoglobin → Heme + Globin
- ☒ Myoglobin
- ☒ Heme-containing enzymes (e.g., CYP_{450})

⇒ Heme → Iron / Protoporphyrin

Protoporphyrin → Bilivirdin → Bilirubin → circulation "UCB or Hembilirubin"

2. Transport

- Unconjugated bilirubin (UCB) is **bound** to albumin (No renal excretion + No CNS)

3. Uptake of bilirubin

- Uptake by the liver (by proteins X & Y)

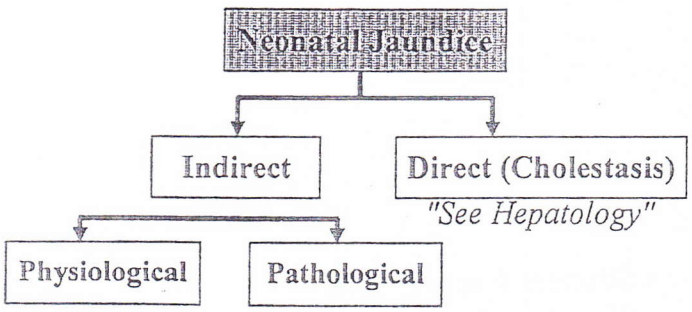
4. Conjugation of bilirubin

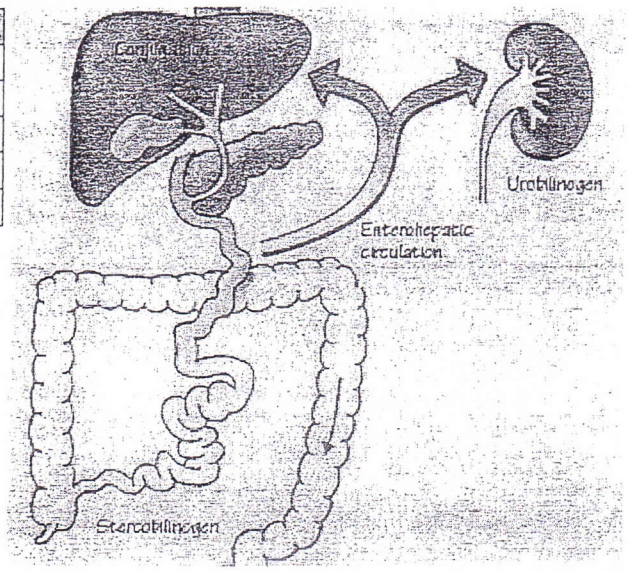
- Conjugation to glucuronic acid (by the enzyme ***UDP-glucuronyl transferase***) forming cholebilirubin (Conjugated bilirubin)

5. Excretion of bilirubin

- Conjugated bilirubin is excreted into the bile → intestine →
  - **a.** Converted* into stercobilinogen (by the intestinal bacteria)
  - **b.** Small amount is deconjugated by glucuronidase → Unconjugated bilirubin → EHC
- Stercobilinogen:
  - **a.** Converted* (by colon air) → Stercobilin → Stools (brown color)
  - **b.** Small amount is reabsorbed into the EHC → Re-excreted by the liver into the bile
    Or → Renal excretion as urobilinogen
    (Converted on standing into urobilin)

Unconjugated bilirubin	Conjugated bilirubin
Hembilirubin	Cholebilirubin
Indirect bilirubin	Direct bilirubin
Bound to albumin	Not bound
Water insoluble	Water soluble
Can't be excreted in urine	Can be excreted in urine





Etiology of Indirect Hyperbilirubinemia

In many neonates with neonatal jaundice, the cause can not be identified

A) ↑↑ Production of bilirubin

1. Hemolytic disease of the newborn
   - Rh incompatibility
   - ABO incompatibility
   - Minor groups (Kell, Kidd, Duffy…)
2. Hemolytic anemia
   - Membrane (Hereditary spherocytosis)
   - Enzyme (G-6-PD deficiency)
   - Hb (α-Thalassemia)
3. Polycythemia (IDM, TTTS…)
4. Enclosed hematoma (cephalhematoma, subgalial hematoma, ICH)
5. Neonatal sepsis
6. ↑↑ Enterohepatic circulation (EHC)
   - CHPS
   - Intestinal obstruction & Hirschsprung disease
   - Inadequate calories
7. Drugs
   - Vitamin K
   - Maternal oxytocin
   - Sulfonamides

B) ↓↓ Uptake

1. Gilbert's syndrome
2. Breast milk jaundice
3. Hypothyroidism
4. Hypoxia & acidosis

C) ↓↓ Conjugation

1. Physiologic jaundice
2. Breast milk jaundice
3. Hypothyroidism
4. Crigler-Najjar syndrome

Gilbert's Syndrome (AD)
- 2-5% of population
- ↓↓ Uptake & conjugation
- Accidentally discovered
- ↑↑ Bilirubin (Indirect)
- **Rx**: Reassurance

Crigler-Najjar syndrome

1. **Type I** (Complete enzyme ↓↓)
   - AR
   - 100% kernicterus
2. **Type II** (Partial enzyme ↓↓)
   - AD
   - Phenobarbitone

Physiological Jaundice

Etiology

A) ↑↑ Production of bilirubin
- ↑↑ RBCs/Kg
- ↓↓ RBCs life span

B) ↓↓ Uptake (Liver immaturity ↓↓ X & Y proteins)

C) ↓↓ Conjugation (↓↓ glucuronyl transferase enzyme)

	Physiological Jaundice	Pathological Jaundice
Onset	2nd or 3rd day	Any time (1st 24 hr)
Rate of ↑↑	< 5 mg/Kg/day	> 5 mg/Kg/day
Peak	12 in full-term, 14 in preterm	>12 in full-term, >14 in preterm
Duration	5-7days in FT, 10-14 in preterm	Longer duration
Conjugated bilirubin	< 20% < 2 mg%	> 20% > 2 mg%

Approach to a case of Neonatal Jaundice

> **Jaundice usually starts in the head → abdomen → limbs**

> **Jaundice is difficult to be detected clinically in preterm & dark-colore infants**

A) History

- Onset of jaundice
- Family history (hemolytic anemia, G-6-PD deficiency…)
- Maternal diseases (DM, TORCH…)
- Maternal drugs (Oxytocin, sulfonamides…)
- Perinatal history (asphyxia, cephalhematoma…)
- Nutritional (breastfeeding…)

1st 24 hr	> 24 hr	Late-onset or prolonged
Hemolytic disease of the NB	Physiological Jaundice	Breast milk jaundice
Hemolytic anemia…	Breast milk jaundice	Hypothyroidism
	Neonatal sepsis	Crigler-Najjar syndrome
	Enclosed hematoma	CHPS
	Crigler-Najjar syndrome	
Cholestasis (TORCH)	Cholestasis (EHBA, Metabolic...)	Cholestasis (EHBA, Metabolic..)

B) Examination

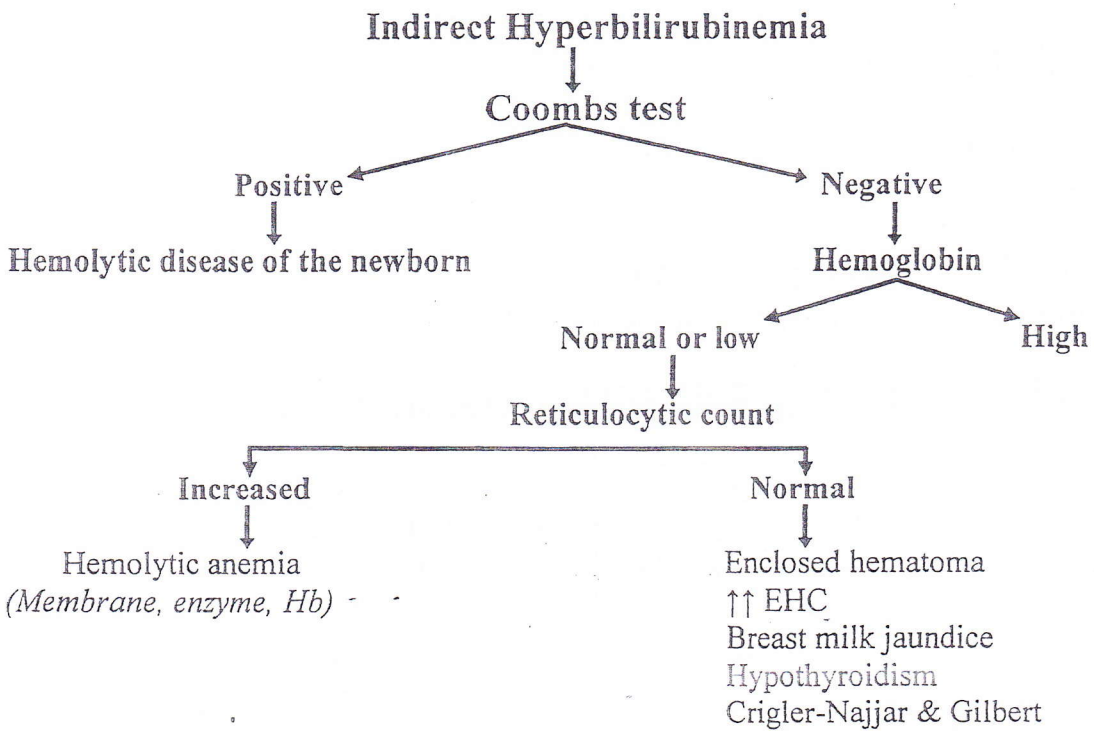
> **Causes of NJ in Down syndrome**
> **1. Annular pancreas**
> **2. Hypothyroidism** (Anti-thyroid Ab)

- Gestational age & weight (for treatment plan)
- Color of jaundice (bright yellow or greenish)
- Color of urine & stools (Clay-colored stools in EHBA)
- Manifestations of TORCH (microcephaly, HSM, rash…)
- Manifestations of neonatal sepsis (poor feeding, poor reflexes…)
- Manifestations of Down syndrome?

C) Investigation

- Laboratory: serum bilirubin (total & direct), CBC, reticulocytic count, coombs test, sepsis screen, thyroid profile, metabolic screen…
- Imaging: Abdominal US for EHBA, organomegaly…
- Invasive: Liver biopsy (In cases of cholestasis)

> **Transcutaneous bilirubin is useful in screening (= TcB)**



Breast milk associated jaundice

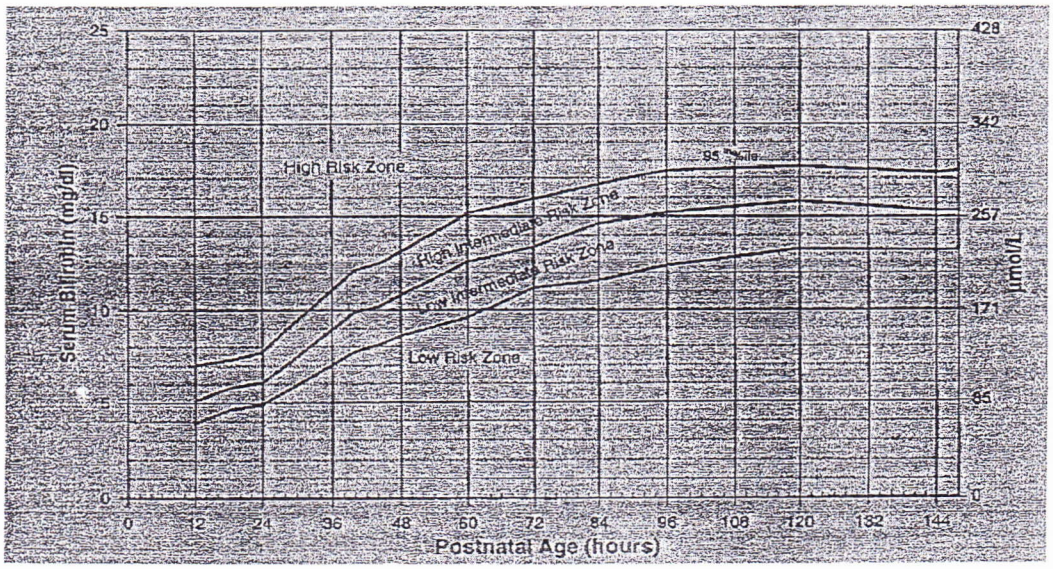
	Breast milk jaundice	Breast feeding jaundice
Incidence	2 %	13 %
Type	Indirect hyperbilirubinemia	Indirect hyperbilirubinemia
Onset	Late-onset > D_7	1st 3-4 days
Bilirubin Level	10-30 mg%	> 12 mg%
Kernicterus	Has been reported	No
Etiology	1. ↓↓ Conjugation (milk pregnandiol) 2. ↑↑ Milk glucuronidase activity 3. ↑↑ Milk lipoprotein lipase activity →↑↑ FFA → ↓↓ uptake & conjugation	1. ↓↓ Milk intake & ↓↓ stooling 2. ↓↓ Caloric intake 3. Dehydration
Treatment	▪ Stop breast feeding for 1-2 days ▪ Phototherapy or exchange transfusion	▪ Frequent breast feeding ▪ Avoid Glucose 5% (↓↓ Calories)

End-tidal carbon monoxide

- Carbon monoxide excretion by the lungs is a by-product of conversion of heme to UCB
- ↑↑ CO is an indicator of ↑↑ production of UCB
- Normal CO excludes hemolysis

Risk of development of significant hyperbilirubinemia

The risk can be identified by the following nomogram



Nomogram for designation of risk in well newborns at ≥ 36 wks & birth weight ≥ 2000 g or ≥35 wk and birth weight ≥ 2500 g. The serum bilirubin level was obtained before discharge, and the zone in which the value fell predicted the likelihood of a subsequent bilirubin level

Kernicterus

(Bilirubin Encephalopathy)

Definition

It is neurological syndrome resulting from deposition of unconjugated bilirubin in the brain; basal ganglia & brain stem nuclei

Incidence

30% of neonates with untreated hemolytic jaundice with bilirubin level > 25-30 mg%

Risk Factors

1. Bilirubin level

There is wide range depending on the weight, gestational age & co-morbid conditions

Suggested maximal UCB concentrations (mg %)

	Uncomplicated course	Complicated course
< 1.000 gm	12	10
1.000-1.250 gm	14	12
1.250-1.500 gm	16	14
1.500-2.000 gm	18	16
2.000-2.500 gm	20	18

Complicated??
Hypoalbuminemia
Hypoxia
Hypoglycemia
Hypothermia
Hemolysis
Acidosis
Meningitis

2. Duration of exposure to hyperbilirubinemia: 2-5 days

3. Factors that ↑↑ free UCB

- Hypoalbuminemia
- Drugs (sulfonamide, rapid infusion of ampicillin…)
- ↑↑ FFA (starvation, hypoglycemia)

4. Factors that ↑↑ permeability of the BBB

- Acidosis
- Asphyxia (hypoxia)
- Prematurity
- Hypothermia
- Hypoglycemia
- Meningitis & seizures

Pathology

a. Gross: Yellow staining of the brain (basal ganglia, thalami, cerebellum & brain stem nuclei)
b. Microscopic: Gliosis & atrophy of nerve cells & fibers

Clinical Picture

A) Acute form

- ☒ **Phase 1 (1-2 days):** Lethargy, poor reflexes, high-pitched cry, seizures, hypotonia
- ☒ **Phase 2 (3-7 days):** Opisthotonus, bulging AF, seizures, hypertonia
- ☒ **Phase 3 (> 1 wk):** Few abnormalities, hypertonia (Apparent recovery)

B) Chronic form

- ☒ **1st year:** Opisthotonus, seizures, rigidity
- ☒ **2nd year:** Choreoathetosis, ↑↑ rigidity, hearing loss
- ☒ **3rd year:** Choreoathetosis, spastic quadriplegia, hearing loss, mental retardation

Prevention

1. Measurement of serum bilirubin in any baby with jaundice at < 24 hrs
2. F/U assessment for jaundice in neonates discharged before 48 hr after birth
3. Universal screening has been recommended
4. Avoid routine supplementation with H_2O or glucose & encourage breast feeding (↑↑ Calories)
5. Proper Rx of jaundice; Use bilirubin graphs (plot bilirubin level against age in hours)
6. Management plan

Management of Unconjugated Hyperbilirubinemia

Introduction

- The need of treatment is known by plotting the bilirubin level on a graph against age in hours
- The absolute level & serial bilirubin measurements identify the need & nature of Rx

I Treatment of etiological cause

☒ Hypothyroidism
☒ Breast milk-related jaundice
☒ Encourage enteral feeding

II Phototherapy

Rationale

Blue-green light (wave length = 425-475 nm) converts UCB to harmless isomers

a. Photo-configurational isomerization
b. Photo-structural isomerization *(forming lumirubin)*

Indications

1. ↑↑ UCB according to special graphs
2. Before & in-between exchange transfusions
3. Prophylactic phototherapy in VLBW, hemolytic disease & in cephalhematoma

Procedure

- Naked except for the eye & ♂ genitalia
- Distance between the baby & the light source should be ≈ 45 cm *(most effective)*
- Continuous exposure (can be interrupted by feedings) "Mother-infant bonding"
- Frequent change of position to allow maximal skin exposure
- **Monitoring:** Temperature every 2 hrs, hydration status & weight (↑↑ daily water requirements by 20%)
- F/U of bilirubin level & removal of phototherapy when low non-toxic level is reached

Effectiveness of phototherapy

- Light wave length
- Distance
- Skin exposure
- Rate of hemolysis

Expected response:
1-3 mg % after 12-24 hrs

- **Skin color is Not a guide to hyperbilirubinemia**
- **Change lamps every 2.000 hr of use**
- **Ordinary fluorescent lamps are useless**

Side Effects

1. Hyperthermia
2. Dehydration
3. Skin rash (erythematous macular rash)
4. Hyperthermia
5. Loose stools
6. Bronze baby syndrome (brownish discoloration in cases of conjugated hyperbilirubinemia)
7. Corneal damage
8. DNA damage (mutations in gonads)

III Maximum-Intensive Phototherapy

☒ Special blue fluorescent lamps
☒ Distance is 15-20 cm from the baby
☒ Fiber-optic phototherapy blanket under the infant's back

IV Exchange Transfusion

Indications

1. Hemolytic diseases of the NB???
2. Hemolytic anemia
3. Sepsis
4. DIC
5. Polycythemia
6. Respiratory depression by drugs or general anesthesia
7. Hypermagnesemia
8. Inborn errors of metabolism (Maple-syrup urine disease)

Blood used in Exchange transfusion

Type of blood: Fresh, warm, washed (↓↓ plasma proteins), irradiated (↓↓ GVHD), CMV free

Blood group:

- Mother O^- ⟶ O^- blood
- Mother O^+ ⟶ O^- or O^+ blood
- Any other group ⟶ Blood group of the baby & Rh of the mother

Volume

Double blood volume = 2 x 85 x Wt

Procedure

A) Assessment

Clinical: Vital signs, weight, gestational age

Lab: Hb%, Hct, bilirubin, reticulocytic count, coombs test, electrolytes, blood glucose, ABG

B) Order blood for exchange [start phototherapy, NPO, Glucose 10%]

C) Steps

- Aseptic (hand washing, sterile gown, gloves, towels…)
- Radiant warmer
- Umbilical vein cannulation
- Alternating withdrawal of 5-20 cc of infant' blood & infusion of equal volume of donor's blood. Simultaneous (isovolumetric)
- The last 10-20cc are transfused to the baby
- 1 cc Ca gluconate is given every 100 cc transfused blood
- Heparin may be used to maintain patency of the umbilical catheter
- Protamine sulphate should be available
- Glucose 25% if hypoglycemia occurs
- **Monitoring:** Vital signs, blood glucose, Ca, ABG
- **Duration:** 45-60 min

D) After exchange

- Phototherapy
- Continue IVF using Glucose 10%
- Antibiotics
- F/U investigation: Bilirubin, CBC, electrolytes, glucose, blood culture

Complications

1. Complications of umbilical vein catheterization
2. Electrolyte disturbances: ↓↓ Ca, ↓↓ glucose, ↑↑ K, Acidosis
3. Infection: Bacteremia, HBV, HCV, HIV, CMV
4. NEC
5. Hypothermia
6. Arrhythmias
7. Volume overload (Heart failure)
8. Bleeding (Thrombocytopenia & ↓↓coagulation factors)
9. GVHD
10. Death (1: 100-300)

Indications in hemolytic disease of NB

1. Cord blood Hb ≤ 10 g%
2. Cord blood Bilirubin ≥ 5 mg%
3. Reticulocytes ≥ 15 %
4. Serum bilirubin > 6 mg% in the 1st 6 hr
5. Serum bilirubin ↑↑ by ≥ 0.5-1 mg%/hr
6. Severe hemolysis in a sibling

V Phenobarbital

Actions

- Hepatic microsomal enzyme inducer
- ↑↑ Conjugation

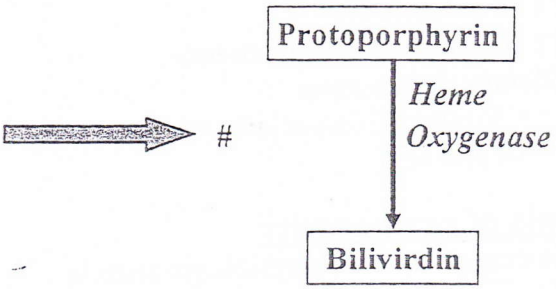
Uses

- Indirect hyperbilirubinemia
- Direct hyperbilirubinemia (2ry to inspissated bile syndrome)
- Crigler-Najjar syndrome type II (partial enzyme deficiency)

Side Effects

- Lethargy, ↓↓ cognitive function
- Slow action

VI Heme Oxygenase Inhibitors (Metalloporphyrins)



Actions

- Inhibition of heme oxygenase
- Still under trials

Indications

Prophylactic when neonatal jaundice is anticipated (e.g., ABO incompatibility…)

Example

Tin & Sn mesoporphyrin (IM)

VII IVIG

Actions

Saturation of spleen & RES Fc receptors with Ig → ↓↓ RBCs destruction

Indications

Isoimmune hemolytic disease (Ab mediated destruction of RBCs) when bilirubin approaches exchange levels despite phototherapy

Dose

0.5-1 g /Kg/dose every 12 hr

Physiologic Anemia of Infancy

Introduction

- **In utero,** oxygen saturation is low (45%) ⟶ Erythropoietin level is high
- Term: Cord blood Hb% = 14-20 g%
- VLBW: Cord blood Hb% = 12-18 g%
- **After birth,** oxygen saturation is (95%) ⟶ Erythropoietin level is low

Etiology

1. ↓↓ **Erythropoiesis** (↓↓ Erythropoietin)
2. ↓↓ **RBCs life span**
3. ↑↑ **Blood volume**
4. ↑↑ **Nutritional requirements**
5. **Dietary deficiencies**
   - Vitamin E (especially with iron supplementation)
   - Folic acid

Iron therapy in neontes with ↓↓ Vitamin E⟶ Hemolytic anemia + Edema + Thrombocytosis

Anemia of prematurity

- It is exaggeration of physiologic anemia
- Preterm neonates have the same (but exaggerated risk factors; *mention*)

Level *(Nadir is the lowest Hb level)*

	Time of nadir (± 3 wk)	Hb% at nadir (± 1 g %)
Term	9	10
Preterm	7	8

Clinical Picture

- Physiological anemia is not a functional anemia (adequate O_2 delivery to the tissue)
- Anemia of prematurity: pallor, tachycardia, tachypnea, poor weight gain, apnea

Prevention

- Vitamin E (15-25 IU/ day)
- Iron supplementation (2-4 mg/Kg/day) should be given once full enteral intake is given
- Folic acid *(routine in some centers)*
- Breast milk (↓↓ linoleic) should be used to maintain ↓↓ PUFA in RBCs membranes
- Recombinant human erythropoietin [r-HuEPO]: 200-250 units/kg SC (3 times/ wk) *can* be used to prevent anemia of prematurity. Supplementation with iron & vitamin E is indicated
- ↓↓ Blood samples

Treatment

Routine use of rH-EPO is not recommended

☒ Asymptomatic: Only F/U. No treatment except if Hb ≤ 7 g%

☒ Symptomatic: Blood transfusion. The decision of transfusion depends on:
- Hb level
- Severity of symptoms
- Co-morbid conditions (mechanical ventilation, BPD, CHD)

Pathological Anemia in the Newborn

Etiology

A) Blood loss

1. Before birth
   - Feto-maternal transfusion
   - TTTS
2. During delivery
   - Placenta: placenta previa, accidental hemorrhage, incision
   - Cord: Velamentous insertion, vasa previa, rupture
3. Neonatal bleeding
   - Head
     - Cranial: Cephalhematona, subgalial hematoma
     - Intracranial: ICH
   - Internal organs

B) ↓↓ Production

Congenital pure red cell aplasia = Diamond-Blackfan syndrome

1. **↓↓ Precursors**
   - Pure red cell aplasia (congenital or acquired "Parvo B_{19}")
   - Constitutional aplastic anemia (Fanconi anemia)
   - Osteopetrosis
   - Congenital leukemia
2. **Normal precursors**
   - Congenital Dyserythropoietic anemia
3. **Specific factors**
   - **Folic acid, B_{12}, Iron**
   - **Proteins, Cu**

C) ↑↑ Destruction

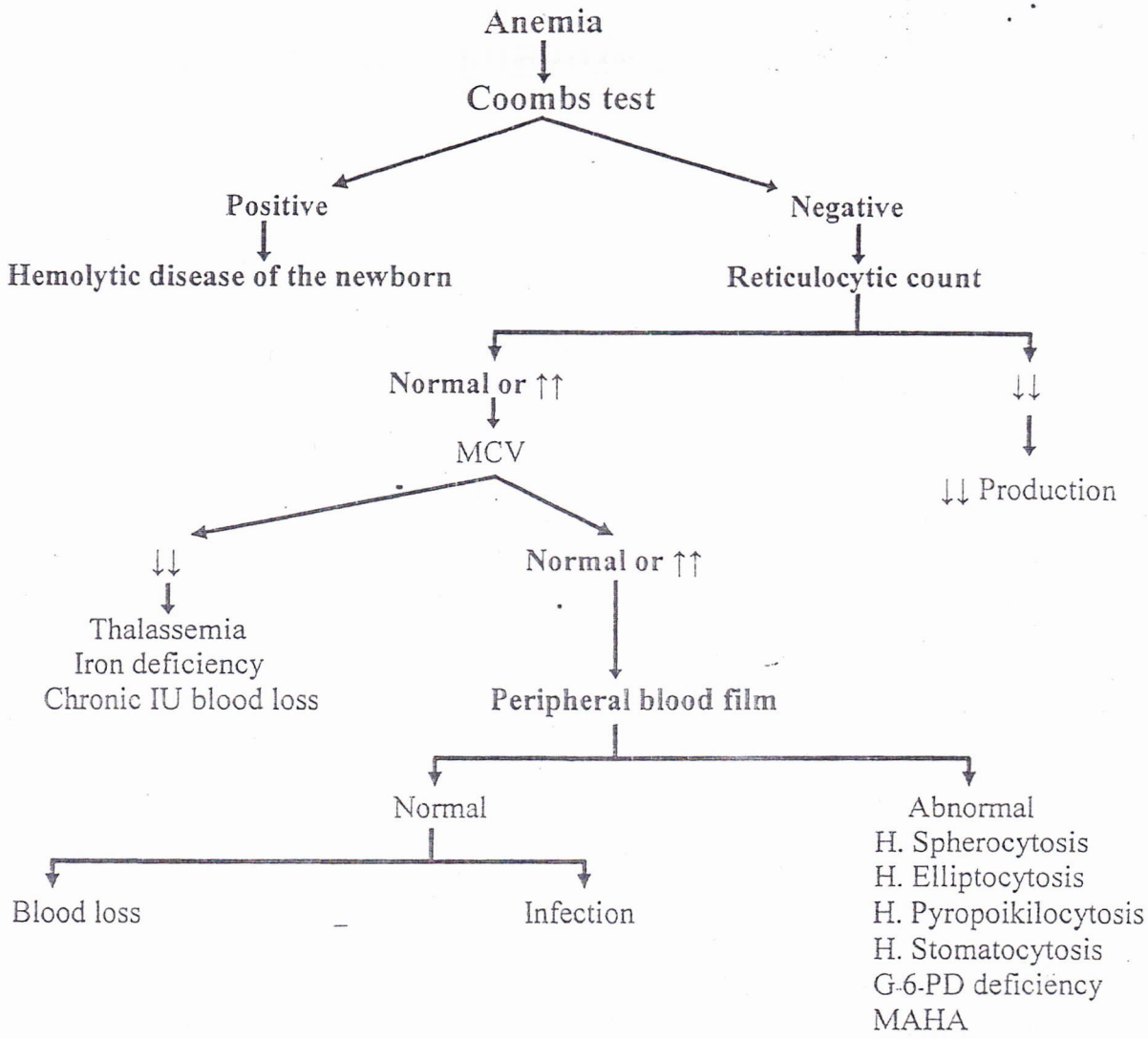
1. Intra-corpuscular
   - Membrane (Hereditary spherocytosis)
   - Enzyme (G-6-PD deficiency)
   - Hb (α-Thalassemia)
2. Extra-corpuscular
   - Immune-mediated
     - Rh, ABO, Minor groups …
     - Maternal autoimmune diseases (SLE)
     - Drug-induced (penicillins, valproate…)
   - Non-immune
     - MAHA (Renal vein thrombosis, DIC…)
     - Infection (sepsis)
     - Vitamin E deficiency

Clinical Picture

- Pallor, tachycardia, tachypnea, poor weight gain, apnea
- Anemic heart failure

Diagnostic Approach (= History + examination + investigation). See diagram

Prevention (as in physiologic anemia + Rx of the cause)



Prevention (as in physiologic anemia + Rx of the cause)

Treatment

A) Blood transfusion

Type of blood:

- Fresh
- Warm
- Filtered (Leukocyte depleted)
- Washed (↓↓ plasma proteins)
- Irradiated (↓↓ lymphocytes)
- CMV free

Volume

10-20 cc/Kg (Smaller volumes should be used with anemic HF)

Indications

1. Hemolytic disease of the newborn & hemolytic anemia
2. Hb < 10-12 g % in neonates with RD to ↑↑ oxygenation
3. Anemic HF
4. Sick preterm (sepsis, pneumonia, BPD)
5. Preterm neonates with apnea & bradycardia
6. Preterm neonates with poor weight gain
7. Asymptomatic infants with Hb < 7 g % & reticulopenia

Packed or whole blood
Whole blood in exchange & blo l loss
Packed RBCs in other indications

B) r-HuEPO *(as before)*

Polycythemia

Definition

Polycythemia is venous blood hematocrit (Hct) > 65% [or Hb ≥ 21 g%]
Plethora is deep red appearance *"Clinical sign"*

Incidence

It is ↑↑ in SGA, post-term babies & at high altitudes (↓↓ O_2)

Etiology

A) **Intrauterine Hypoxia-IUGR** (↑↑ Erythropoietin)
B) ↑↑ **Blood volume**
- Materno-fetal transfusion
- TTTS
- Placental transfusion (delayed cord clamping or holding the baby below the mother)

C) **Other causes**
- IDM, LGA & Beckwith-Wiedmann syndrome
- Trisomies 21, 13, 18
- Throtoxicosis &7 hypothyroidism

Clinical Picture

☒ Asymptomatic
☒ Facies: Plethora
☒ CNS: lethargy, seizures, stroke
☒ CVS: Heart failure
☒ Respiratory system: RD or apnea
☒ GIT: Feeding difficulties & ↑↑ risk of NEC
☒ Metabolic: hypoglycemia, hypocalcemia, hyperbilirubinemia

Hyperviscosity

Investigations

- Hct
- Blood viscosity (viscometer)

Prevention

- Antepartum management of placental insufficiency…
- Intrapartum: avoid *milking* of the cord, avoid holding the baby below the placenta

Treatment

☒ **Symptomatic:** Partial exchange transfusion using fresh plasma or normal saline

Volume of exchange = Blood volume X $\frac{\text{Observed Hct} - \text{Desired Hct}}{\text{Observed Hct}}$

Comlications: Complication of vascular access (umbilical venous catheter)

☒ **Asymptomatic:**
a. Hct = 65-70% ⟶ Close observation + IV fluids
b. Hct > 70% ⟶ Partial exchange transfusion

Prognosis

- ↓↓ IQ
- Speech deficits & learning difficulties
- Complications of umbilical venous catheter (e.g., portal hypertension…)

Hemolytic Disease of the Newborn

(Erythroblastosis Fetalis)

Definition

Transplacental passage of maternal antibodies causing hemolysis of the fetal RBCs
It is caused by Rh, ABO or minor group incompatibility (Kell, Kidd, Duffy…)

Anti-D Abs occur with:
1. Blood transfusion
2. Pregnancy, abortion or delivery

Rh Incompatibility

Introduction

- The Rh system is controlled by 3 pairs of alleles, the most important is D & d alleles
- D allele is dominant over d (DD & Dd are Rh positive)
- Other alleles are C, c, E, e
- Antibodies against Rh system *(Anti-D Antibodies)* are Not naturally occurring & of IgG type

Pathogenesis

- If the mother is Rh negative & the father is Rh positive, the baby may be Rh positive
- Minute amounts of fetal RBCs pass to the maternal circulation during abortion or delivery causing maternal sensitization (formation of Anti-D Antibodies)
- In **subsequent** pregnancies, maternal anti-D antibodies cross the placenta, reacting with fetal RBC, causing hemolysis
- These events can occur in the 1st pregnancy if the mother was **previously** sensitized
- Fetal hemolytic anemia (anemia, HF, extramedullary hematopoiesis, bilirubin is not ↑↑)??

Incidence

Only 5% of babies borne to **Rh-negative mothers** develop hemolytic disease. Why?

1. The father may be heterozygous
2. Feto-maternal transfusion occurs in only 50% of pregnancies
3. Variable D antigenicity
4. Variable maternal antibody response
5. Concomitant occurrence of ABO incompatibility (↓↓ maternal sensitization)

Clinical Picture (spectrum with variable severity)

1. **Hemolytic anemia:** pallor, tachycardia, tachypnea
2. **Anemic heart failure:** generalized edema, hepatomegaly, pleural & pericardial effusion
3. **Hydrops**
4. **HSM:** extramedullary hematopoiesis
5. **Hepatic dysfunction:** ↓↓ Albumin
6. **Portal hypertension:**
7. **Ascites**
8. **Hemolytic jaundice:** Unconjugated hyperbilirubinemia is evident within the 1st day
9. **Kernicterus:** D_2-D_5
10. **RD:** pulmonary congestion, pulmonary edema or pleural effusion
11. **Thrombocytopenia:** 2ry to BM inhibition or DIC
12. **Hypoglycemia:** 2ry to pancreatic cell hyperplasia ⟶ hyperinsulinism

Prevention

1. **Avoid exposure of ♀ to Rh +ve blood**
2. **Anti-D antibodies: [1 cc = 300 µg]**
   - Given IM to the mother within 48-72 hr of placental separation (abortion, labor…)
   - More effective if given at 28-32 wks and at birth

Diagnosis

A) Antenatal diagnosis

The mother at risk:

- Rh-negative with the father is Rh-positive
- History of blood transfusion, pregnancy or abortion
- History of previously affected infant

1. Maternal serum titer of IgG anti-D antibodies

- ☒ Done at 12-16 wk, 28-32 wk & at 36 wk
- ☒ Titer ≥ 1:16 should be further investigated (Severe if titer ≥ 1:64 or rising titer)

2. Fetal U/S (real time & Doppler)

- ☒ Hydrops: pleural, pericardial effusion, ascites, skin edema, HSM
- ☒ Biophysical profile & Doppler
- ☒ Amniocentesis

3. Amniocentesis

- ☒ Done at 18-20 wk & at 1-2 wk intervals if titer ≥ 1:16 or positive US
- ☒ Measurement of UCB in the amniotic fluid by spectrophotometry
- ☒ The risk is categorized by 3 zones
  - Zone 1: Mild disease
  - Zone 2: Moderate disease
  - Zone 3: Severe disease (impending fetal death)

Change in the optical density

4. PUBS (Percutaneous umbilical blood sampling)

- ☒ Done if the OD deviation is in zone 3
- ☒ Measurement of Hb & Hct
- ☒ Blood transfusion is indicated if Hct < 25%

B) Postnatal diagnosis

- ☒ Coombs: positive
- ☒ Hb & Hct: ↓↓
- ☒ Bilirubin: ↑↑
- ☒ Reticulocytic count: ↑↑

Any NB born to Rh-negative mother:

- **ABO, Rh**
- **HB, Hct**
- **Coombs test**

Treatment

A) Antenatal [Aim = prevention of **hydrops**]

1. Induction of labor

- If ≥ 33 wk + zone 2 or 3 OD deviation
- Risk of prematurity should be considered

2. IU intraumbilical blood transfusion

- Fresh, irradiated, group O, Rh negative blood (cross-matched to maternal serum)
- Risk of the procedure & GVHD

B) Postnatal [Aim = prevention of **kernicterus**]

1. **Stabilization:** Respiratory support, packed RBCS, correction of acidosis
2. **Exchange transfusion.** When?
3. **Phototherapy**
4. **IVIG**
5. **Metalloporphyrin**

DD

Other causes of hydrops

Hydrops Fetalis

Definition

It is excessive abnormal accumulation of fluid in ≥ 2 fetal compartments
[Peritoneum, pericardium, pleura, placenta, amniotic fluid, skin]

Etiology

1. **Immune hydrops:** Rh incompatibility
2. **Idiopathic**
3. **Anemia:** All causes of pathological anemia of the newborn can cause hydrops
4. CVS
   - Arrhythmias: SVT, congenital heart block
   - Structural: HLHS, complete AV canal, cardiomyopathy
   - Vascular: cerebral AV malformation (aneurysm of vein of Galen)
     Klippel-Trenaunay syndrome
     Chorioangioma of the cord or placenta
   - Lymphatics: Turner, Noonan, cystic hygroma, lymphangiectasia (chylous ascites…)
5. **CNS:** encephalocele, myotonic dystrophy
6. **Lungs:** congenital diaphragmatic hernia, cystic adenomatoid malformation
7. **Renal:** congenital nephrosis
8. **GIT:** Intestinal obstruction
9. **Tumours:** Neuroblastoma, hepatoblastoma, teratomas
10. **Metabolic:** Gaucher', Niemann-Pick, MPS
11. **Chromosomal:** Trisomies 21, 13, 18
12. **Bone sdisease:** Osteogenesis imperfecta, skeletal dysplasia
13. **Congenital infection:** TORCH, Parvovirus B_{19}
14. IDM

C/P Investigation Treatment

ABO Incompatibility

Introduction

- Antibodies (agglutinins) against ABO system are naturally occurring & of IgM type
- Sometimes antibodies are of IgG type that can cross the placenta, reacting with fetal RBCs, causing hemolysis

Pathogenesis

- If the mother is group O & the fetus is group A, B or AB
- Maternal anti-A & anti-B antibodies cross the placenta, causing fetal RBCs hemolysis
- It may occur in the 1st born infant

Incidence

Only 10% of babies borne to **group O mothers** develop hemolytic disease. Why?

1. Antibodies are usually of IgM type
2. ABO antigenicity is usually low

Clinical Picture

- Unconjugated hyperbilirubinemia may be evident within the 1st day
- Hydrops, kernicterus are rare

Investigations (as postnatal diagnosis of Rh incompatibility)

Treatment (as postnatal Rx of Rh incompatibility)

Hemorrhagic Disease of the Newborn

Action of Vitamin K

- Carboxylation of coagulation factors
- Carboxylation of glutamic acid in the developing cartilages

Definition

Transient deficiency of vitamin K dependent coagulation factors (II, VII, IX, X)

Predisposing Factors

1. ↓↓ Store (more in preterm)
2. ↓↓ Intake (breast milk is poor in vitamin K)
3. ↓↓ Synthesis (↓↓ intestinal flora)
4. Liver immaturity
5. Broad-spectrum antibiotics
6. Malabsorption (fat-soluble vitamin)
7. Maternal drugs (Phenobarbitone, phenytoin, warfarin)

Clinical Picture

	Early-onset	Classic disease	Late-onset
Onset	1st 24 hr	D_2-D_7	1-6 months
Incidence	Very rare	2 %	Variable
Site	▪ Cephalhematoma ▪ Subgalial hematoma ▪ ICH ▪ GIT	▪ GIT ▪ Nose, ear, mucosal ▪ Circumcision ▪ Injection sites	▪ ICH ▪ GIT ▪ Nose, ear, mucosal ▪ Injection sites
Etiology	Maternal drugs	Vitamin K deficiency	Malabsorption
Prevention	▪ Avoid high risk drugs ▪ Vit K to mother& baby	Vit K 0.5-1 mg IM (or several oral doses)	IM or oral vit K supplementation

Apt test:
Test done in GIT bleeding to detect maternal RBCs

Kleihauer test:
Test on maternal blood to detect fetal RBCs

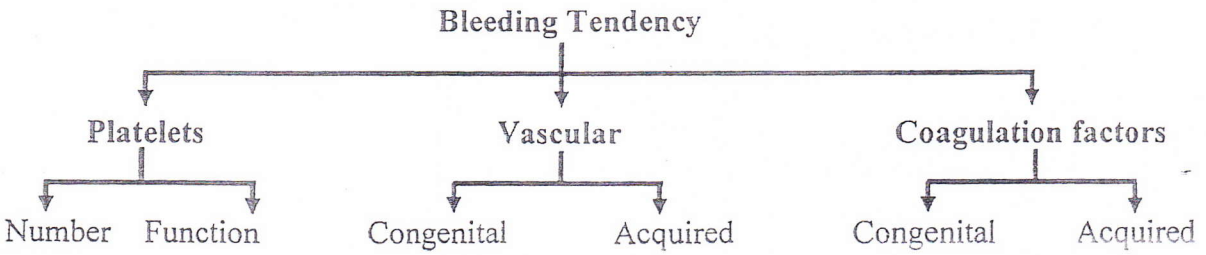
Investigations

☒ ↑↑ PT, ↑↑ PTT
☒ Bleeding time, platelet number & function: Normal
☒ PIVKA (= protein induced in vit K absence): ↑↑

Treatment

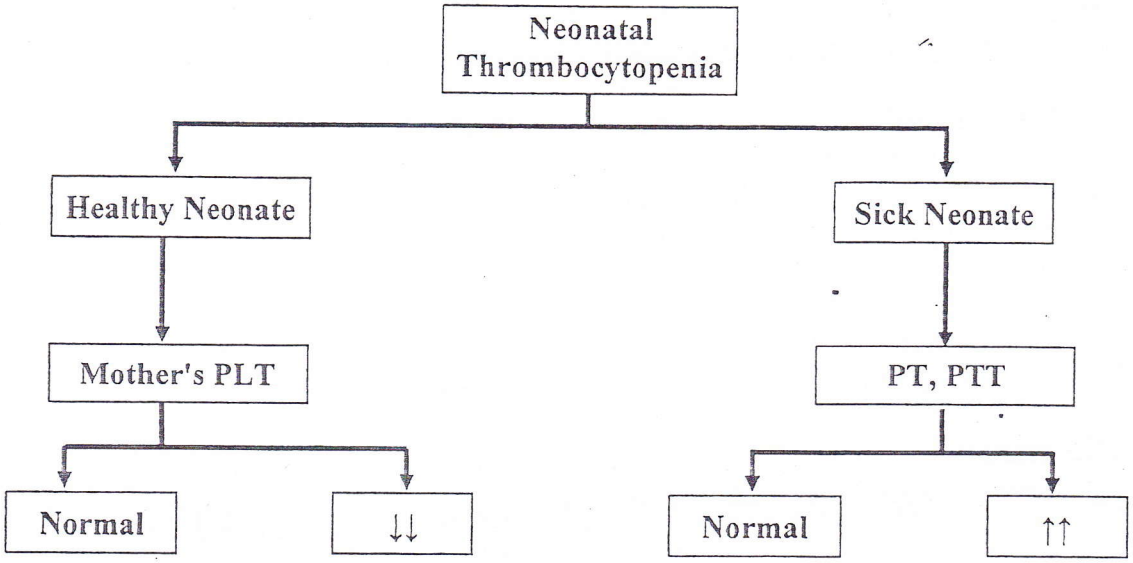
☒ **Vitamin K (Konakion):** 1-5 mg IV
☒ **Fresh frozen plasma:** 10 cc/Kg in cases of serious bleeding
☒ **Whole blood transfusion:** in cases of marked hemorrhage

Differential Diagnosis [Bleeding tendency in neonates]



Neonatal Thrombocytopenia

Etiology



1. NATP
2. Fanconi anemia
3. Amegakaryocytic thrombocytopenia
4. Wiskott-Aldrich
5. ↓↓ Thrombopoietin
6. TAR syndrome
7. Kasabach-Merrit

1. Maternal ITP
2. Maternal SLE
3. Maternal drugs

1. NEC
2. Infection (without DIC)
3. BM infiltration

1. Sepsis
2. DIC
3. Hypoxia
4. Acidosis
5. Hypothermia

Retinopathy of Prematurity

Definition

It is a disease of the immature, incompletely vascularized retina in premature infants treated with O_2 at high concentration

Incidence

65% of preterm neonates < 1.250 g
80% of preterm neonates < 1.000 g
10% of causes of visual impairment in developed countries

VEGF =
Vascular endothelial growth factor

Risk Factors

1. Prematurity**
2. Low birth weight**
3. Hyperoxia & hypoxia
4. Hypercapnia & hypocapnia
5. Acidosis & alkalosis
6. Mechanical ventilation
7. BPD
8. Vitamin E deficiency
9. Sepsis
10. Intra-ventricular hemorrhage

Pathogenesis

☒ ↑↑ O_2 ⟶ Retinal VC⟶ Vascular endothelial growth factors (VEGF)⟶ Inappropriate & excessive growth of retinal vessels ⟶ BV invade the vitreous body ⟶ Vitreous hemorrhage ⟶ Fibrosis ⟶ Retinal detachment

☒ Developmental retinal arrest

Screening

	USA	UK
Who??	< 1.500 g < 29 wk	< 1.500 g < 32 wk
When??	4-6 wk chronological age 31-32 wk PCA	6-7 wk chronological age
Follow-up	Until regression of retinopathy Or until 36 wk PCA (if no disease)	

Stages

	Description	Treatment
Stage 1	Flat demarcation line between normally vascularized & non-vascularized retina	No Rx (F/U) Spontaneous resolution
Stage 2	Ridge demarcation…	
Stage 3	New blood vessels ± Vitreous hemorrhage	Cryotherapy Laser photocoagulation
Stage 4	Partial RD	Retinal Reattachment
Stage 5	Complete RD	
Plus disease	Active progressive disease	Laser photocoagulation

Prevention

1. Prevention of prematurity
2. Keep O_2 tension between (50-70 mmHg)
3. Use the least possible FiO_2 for the least possible duration
4. Vitamin E supplementation
5. Anti-oxidants

The risk of hypoxic brain damage should be balanced against the risk of blindness from too much O_2

Osteopenia of Prematurity

(Metabolic bone disease of prematurity)

Definition

It is defective bone mineralization affecting premature infants

Incidence

30% of VLBW

Etiology

A) ↓↓ Ca & ↓↓ PO_4*

1. Dietary deficiency (unsupplemented breast milk, term formula for preterm infants…)
2. Loss of PO_4 in urine (Fanconi syndrome)
3. Loss of Ca in urine (furosemide therapy)
4. TPN

B) **Vitamin D Deficiency**

1. Maternal Vitamin D deficiency
2. ↓↓ Intake
3. ↓↓ Absorption
4. ↓↓ Activation
   - ☒ Hepatic
   - ☒ Renal
5. Type 1 vitamin D dependent rickets
6. Type 2 vitamin D dependent rickets
7. Anticonvulsant therapy (phenytoin, phenobarbitone)

Clinical Picture

- Deformities
- Pathologic fractures
- Rickets-like (wide AF, frontal bossing, enlarged ends of long bones, rosary beads…)
- Hypotonia

Investigations

- **Ca:** Normal or ↓↓
- **PO_4:** ↓↓
- **Alkaline phosphate:** ↑↑
- **X-ray:** broadening, cupping, fraying, ↓↓ bone density,
- **Densitometry**

Prevention

- Prevention of prematurity
- Proper maternal nutrition (Ca, vitamin D)
- Dietary management: fortified breast milk or LBW formula for preterm infants

Treatment

- Vitamin D (400-1.000 IU/day)
- Calcitriol: in cases of defects of vitamin D metabolism (hepatic or renal)
- Ca supplementation
- Treatment of fractures

Hypomagnesemia

Mg = 1.5-2.6 mg%

Definition

Serum Mg < 1.5 mg. Clinical manifestation occur when Mg < 1.2 mg%

Etiology

1. Idiopathic with hypocalcemia
2. IDM
3. Iatrogenic: exchange transfusion, TPN
4. Malabsorption (generalized or specific)
5. ↑↑ Renal excretion (Hereditary AD, drugs; aminoglycosides, amphotericin B)

Clinical Picture

- As hypocalcemia (tetany & convulsions)

↓↓ Mg should be considered in any case of tetany not responding to IV Ca

Treatment

- IV Magnesium sulphate 10%: slowly (1 cc/Kg)
- Oral maintenance therapy

Hypermagnesemia

Definition

Serum Mg > 2.6 mg. Clinical manifestation occur when Mg > 5 mg%

Etiology

1. Maternal $MgSO_4$ (Rx of eclampsia)
2. $MgSO_4$ enema
3. Mg-containing antacids
4. TPN (↑↑ Mg)

Clinical Picture

- Lower levels: Lethargy, hypotonia, hyporeflexia, hypotension,
- High levels: CNS depression & paralysis (mechanical ventilation may be needed)

Treatment

- Removal of the source of Mg
- Respiratory support may be needed
- IV Calcium gluconate 10%: slowly (1 cc/Kg)
- Diuretics
- Exchange transfusion

Hypocalcemia

Hypercalcemia

Hypothermia

Estimated heat loss in neonates is **4 times** that of an adult.
Preterm NB is at a **greater risk**

Definition

It is body temperature ≤ 35°C

Premature neonates are at risk due to

1. Skin: thin with ↑↑ permeability
2. Skin: ↑↑ surface area
3. Skin: ↓↓ SC fat
4. Not able to curl-up
5. Brown fat: ↓↓ FA oxidation
6. Caloric intake: ↓↓
7. Activity: ↓↓
8. O_2 consumption: ↓↓ (respiratory problems; RDS…)
9. No shivering (till 2weeks of age)

Mechanism of heat loss

	How is heat lost…	How to avoid…
Convection	Heat loss from the skin to the moving cooler **air**	▪ Clothing ▪ Boots & hats ▪ ↑↑ Room air Temperature ▪ Avoid drafts
Radiation	Heat loss from the skin to cooler **objects** in the environment	▪ Double-walled incubators
Evaporation	Heat loss from moist skin & lungs (with H_2O)	▪ Dryness (immediately after birth) ▪ Wrapping (warm towels) ▪ ↑↑ Room air Humidity ▪ Use of warm humidified air/O_2
Conduction	Heat loss from the skin to cooler surfaces **in contact** with the baby	▪ Heated mattresses

Clinical Picture

- ☒ Temperature ≤ 35°C
- ☒ Facies: Facial erythema, rhinitis
- ☒ Edema & local hardening
- ☒ CNS: Coma
- ☒ CVS: Bradycardia & hypotension
- ☒ Respiratory system: apnea & pulmonary hemorrhage
- ☒ GIT: Feeding difficulties & ↑↑ risk of NEC
- ☒ Metabolic: hypoglycemia, acidosis
- ☒ Blood: thrombocytopenia, DIC

Do not allow the newborn to get cold.
Hypothermia:
- Acidosis
- Hypoglycemia

Prevention

- Any neonatal examination should be done under radiant warmers
- Incubator care & radiant warmer

Treatment

- Warming
- Correction of metabolic disturbances (hypoglycemia, acisosis)

Prognosis

- Mortality = 10%
- Brain damage in 10% of survivors

Hypoglycemia

Normal neonates produce **4-5 mg/Kg/minute** of glucose to maintain glucose homeostasis

Definition *(differs according to the age)*

1-3 hours: blood glucose level < 35 mg%
3-24 hours: blood glucose level < 40 mg%
After 24 hours: blood glucose level < 45 mg%

Incidence

1-3: 1000 live births

Etiology

A) Hyperinsulinism

1. IDM, LGA & Beckwith-Wiedmann syndrome
2. Erythroblastosis Fetalis (pancreatic cell hyperplasia)
3. Hyperinsulinemic hypoglycemia of infancy (HHI): previously called "nesidioblastosis"
4. Maternal drugs: Sympathomimetics (tocolytics), thiazides, large glucose infusion

B) ↓↓ Glycogen stores

1. Prematurity
2. SGA (IUGR)
3. ↓↓ Intake

C) ↑↑ Requirements

1. RDS, HF, hypothermia
2. Polycythemia

Persistent Hypoglycemia
1. HHI
2. Metabolic
3. Endocrinal

D) ↓↓ Production

1. HIE
2. Maternal β-blockers (propranolol)
3. Defects in Carbohydrates metabolism
   - Glycogen storage disease
   - Galactosemia
   - Hereditary fructose intolerance (↓↓ Aldolase B)
4. Defects in Fat metabolism
   - FA oxidation defects (hypoketotic hypoglycemia)
5. Defects in Protein metabolism
   - Tyrosinemia
   - Maple syrup urine disease
   - Propionic academia
6. Endocrinal causes
   - Congenital hypopituitarism
   - Adrenal insufficiency

E) Iatrogenic

1. Exchange transfusion
2. Sudden cessation of IVF or TPN

Clinical Picture

A) **↑↑ Catecholamines:** Tachycardia, palpitation, pallor, sweating, tremors
B) **Cerebral glucopenia:** Headache, hunger, drowsiness, confusion, coma, convulsions

Investigations

- Serial blood glucose monitoring every 1 hr (for 6-8 hrs)till readings > 40 mg%
- Investigations of the cause (e.g., reducing substance in urine, hormonal assay…)

Treatment

A) **At-risk asymptomatic neonates with normal blood glucose** (IDM, LGA, SGA…)
- ☒ Close monitoring of blood glucose
- ☒ Early oral or Ryle feeding
- ☒ IVF can be used if there is no response (after 2 hrs) or if there is CI of enteral feeding
- ☒ IDM < 2 Kg should start IVF (↓↓ Glycogen stores): 4-5 mg/Kg/minute

B) **Asymptomatic hypoglycemia**
- ☒ IV glucose 10% (2 cc/Kg)
- ☒ Followed by continuous infusion at 4-5 mg/Kg/minute

C) **Symptomatic hypoglycemia (No seizures)**
- ☒ IV glucose 10% (2 cc/Kg)
- ☒ Followed by continuous infusion at 8 mg/Kg/min

$$\text{GIR} = \frac{\text{Fluid rate (cc/hr) X Glucose Conc. \%}}{6 \text{ X Body weight}}$$

D) **Symptomatic hypoglycemia (Seizures)**
- ☒ IV glucose 10% (4 cc/Kg)
- ☒ Followed by continuous infusion at 8 mg/Kg/min

E) **Persistent hypoglycemia**
- ☒ Glucose infusion rate 10-12 mg/Kg/min
- ☒ Glucose concentration can be ↑↑ up to 12% (peripheral line) or 20% (Central line)

F) **After stabilization**
- ☒ Gradual tapering of IV glucose
- ☒ Gradual advancement of oral feedings

G) **Other lines of management (resistant cases; HHI)**
- ☒ Hydrocortisone (2.5 mg/Kg/12 hr)
- ☒ Diazoxide
- ☒ Octreotide
- ☒ Glucagon
- ☒ Subtotal pancreatectomy (HHI)

Prognosis

- ☒ Good in properly treated infants
- ☒ Neurological sequelae occur with prolonged hypoglycemia (CP)
- ☒ Primary etiology

NB: White classification

Class	Comment
Gestational Diabetes **GD diet** **GD insulin**	Diabetes not known before pregnancy Diabetes controlled by diet only Requires insulin
Class A	Prediabetes (History of large babies > 4 Kg)
Class B	Onset > 20 yrs of age
Class C	Onset at 10-19 yrs of age
Class D	Onset < 10 yrs of age
Class F	Nephropathy
Class R	Retinopathy
Class RF	Both
Class G	Many reproductive failures
Class H	Heart disease
Class T	Prio renal transplantation

Treatment

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Infant of Diabetic Mother

Introduction

A) **Effects of pregnancy on maternal DM** "Diabetogenic"
- Alimentary glucosuria
- Renal glucosuria
- Production of anti-insulin: estrogen, progesterone, cortisol, placental insulinase enzyme, human placental lactogen (hPL)

B) **Effects of DM on pregnancy (mother & fetus)**
- Abortion
- IUFD
- Prematurity
- Pregnancy-induced hypertension (PIH)
- Polyhydramnios
- Congenital anomalies (cardiac, sacral…)
- Macrosomia
- Obstructed labor
- Birth injury
- Neonatal hypoglycemia
- Neonatal hypocalcemia
- RDS
- Polycythemia
- Neonatal jaundice

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- Congenital anomalies (cardiac*, sacral*…)
- Macrosomia
- Obstructed labor
- Birth injury
- Neonatal hypoglycemia
- Neonatal hypocalcemia & hypomagnesemia
- RDS
- Polycythemia
- Neonatal jaundice

Pathophysiology

Maternal hypoglycemia-fetal hyperinsulinemia

☒ Maternal hyperglycemia ⟶ Fetal hyperglycemia ⟶ pancreatic cell hyperplasia ⟶ Fetal hyperinsulinemia ⟶ ↑↑ Uptake & utilization (3) of glucose ⟶ Macrosomia

☒ Placental separation ⟶ ↓↓ glucose delivery to the fetus.

☒ Hyperinsulinemia ⟶ Neonatal hypoglycemia

☒ Hyperinsulinemia ⟶ Surfactant deficiency (RDS)

Clinical Picture

Causes of LBW in IDM:
1. Preterm delivery
2. Placental insufficiency

1. Birth weight: macrosomia
2. Plethora
3. Neonatal hypoglycemia (25-50%)
4. Neonatal hypocalcemia: tetany & convulsions
5. Polycythemia (30%): due to hyperinsulinemia (↑↑ Erythropoietin) & fetal hypoxia
6. Neonatal jaundice: due to polycythemia, prematurity & glycosylation of RBC membrane
7. Cardiomegaly (30%) & HF: due to ventricular septal hypertrophy "HCM"
8. RD:
   - Cardiac lesions (Heart failure)
   - Respiratory: TTN, RDS, pneumonia
   - Polycythemia
   - Hypoglycemia
   - PPHN: (↓↓ Glucose, ↓↓ Ca, HF, Polycythemia)
9. Congenital anomalies:
   - Cardiac: Ventricular septal hypertrophy, VSD, ASD, TGA
   - Sacral agenesis
   - Renal: dyplasia
   - GIT: small left colon syndrome
   - CNS: anencephaly, meningocele
10. Renal vein thrombosis

White classification

It is used to estimate prognosis and perinatal outcome; Complications are:

☒ Minimal in infants of mothers with **gestational** diabetes

☒ High in infants of diabetic mothers with renal, cardiac, or retinal disease

Investigations

- Serial blood glucose monitoring every 1 hr (for 6-8 hrs) till readings > 40 mg%
- Investigations of complications (e.g., Hct, Ca, bilirubin, ABG, CXR, echocardiography…)

Management

A) Antepartum Management

- Antenatal care for early diagnosis & control of DM
- Proper assessment of gestational age
- Antepartum assessment of fetal well being (= Diagnosis of placental insufficiency??)
- Assessment of fetal functional maturity (lung maturity, how?)
- Diagnosis of fetal congenital anomalies
- Steroids for prevention of RDS
- Delivery in an equipped hospital

B) Intrapartum Management

- Intrapartum assessment of fetal well being??
- Resuscitation & Stabilization
- Proper management of expected complications (↓↓ G, Resp. support, birth injury...)

C) Postpartum Management

- Nursery care *(as before)*
- Management of potential complications
  - ➢ Nutrition & hypoglycemia *(see before)*
  - ➢ Respiratory complications: Respiratory support
  - ➢ Neonatal jaundice, Polycythemia, hypocalcemia, hypomagnesemia *(discuss briefly)*
  - ➢ Hypertrophic cardiomyopathy
    - Propranolol
    - Digitalis & other inotropic agents are contraindicated "Obstructive lesion"
    - Resolution usually occurs by the age of 2 wks

Prognosis

- Childhood obesity
- Impaired intellectual development (neonatal hypoglycemia, polycythemia, birth injury…)

Beckwith-Wiedmann Sndrome

Etiology

Sporadic (? familial)

Clinical Picture

- Fetal overgrowth
- Macrosomia
- Macroglossia
- Polycythemia
- Visceromegaly (HSM & nephromegaly)
- Omphalocele
- Characteristic ear lobe crease
- Hemihypertrophy
- Hhypoglycemia
- ↑↑ risk of neoplasms (Wilms tumor)

Investigations

- Serial blood glucose monitoring
- Genetic studies: Partial duplication of chromosome 11p

Treatment

Persistent hypoglycemia

Prognosis

Poor

Birth Injury

Definition

- Any mechanical or anoxic trauma occurring in the infant during labor or delivery
- It may be avoidable or unavoidable
- It may be due to deficient medical skill or attention or not

Incidence

3: 1000 live births with a mortality of 3.7:100.000

Predisposing Factors

- Cephalopelvic disproportion
- Abnormal presentation (Breech…)
- Prematurity
- VLBW
- Prolonged labor
- Precipitate labor
- Instrumental delivery
- Macrosomia
- Maternal factors: Short stature, primiparity

Cranial Injuries

1. Caput succedaneum, Cephalhematoma, Subgaleal hemorrhage

	Caput succedaneum	Cephalhematoma	Subgaleal hemorrhage
Composition	Edema	Blood	Blood
Site	SC tissue Over the presenting part	Subperiosteal Parietal bone* (± bilateral)	Under aponeurosis Entire length of the scalp
Onset	At birth	Few hours after birth	At birth
Extent	Cross suture lines	Localized by suture lines	Cross suture lines
Consistency	Soft (edema)	Firm (± fracture)	Fluctuant
Resolution	Few days	Weeks to months	2-3 weeks
Associations	Skin ecchymosis	Fracture, anemia, jaundice	Fracture, anemia, jaundice
Investigation	No	Hb%, bilirubin, X-ray, CT	Hb%, bilirubin, X-ray, CT
Rx	No	Anemia, jaundice Aspiration is CI	Anemia, jaundice Aspiration is CI

Cephalhematoma Vs Cerebral Meningocele:

2. Pulsating
3. Tense on crying
4. Skull X-ray: Bone defect

2. **Skin** (Erythema, abrasions, ecchymosis): Forceps delivery
3. **Eye** (Subconjunctival & retinal hemorrhage): 2ry to ↑↑ ICT during delivery of the chest
4. **Skull fractures**
   a. **Linear*:** No symptoms, No Rx
   b. **Depressed:** Focal neurological manifestations. Surgical elevation is recommended even if asymptomatic

Intracranial Hemorrhage

Incidence

- ↑↑ with ↓↓ gestational age & birth weight
- 10-20% of infants 1.000-1.500 gm
- 60-70% of infants 500-750 gm

> **Germinal Matrix:**
> - Immature capillary network overlying the caudate nucleus
> - It disappears at ≈ 32 wks

Sites

1. **Extracerebral:** Subdural, Epidural, Subarachnoid
2. **Parenchyma**
3. **Intraventricular:** From subependymal germinal matrix or choroid plexus

Full-term ⇒ **IVH & Subependymal germinal matrix hemorrhage**

Premature ⇒ **Subdural & Subarachnoid hemorrhage** (Traumatic)

Pathogenesis

The major neuropathologic lesions in VLBW are:

A) **IVH:** From subependymal germinal matrix or choroid plexus

B) **Periventricular leukomalacia (PVL):**
- Pathology: White matter damage in the periventricular area
- Cause: Hypoxia, ischemia, IVH, systemic BP fluctuation with impaired cerebral autoregulation (= Maintenance of cerebral BF over a wide range of BP)
- Result: Motor abnormalities, CP
- Prevention: Antenatal steroids, PGs inhibitors (Indomethacin)
- Diagnosis: Cystic lesions of PVL become evident on cranial US ≥ 3 wks after the insult

Etiology

A) **Vascular & Extravascular structural factors**
- ☒ Trauma: See before ( )
- ☒ Hypoxic-ischemic injury to the germinal matrix
- ☒ Congenital vascular anomalies
- ☒ Bleeding tendency: Thrombocytopenia, Coagulopathy, DIC (*Discuss*)

B) ↑↑ **Inflow** (↑↑ Cerebral BF)
- ☒ Convulsions
- ☒ Hypertension
- ☒ Hypercapnia & Hypoxemia
- ☒ Apnea
- ☒ PDA
- ☒ Infusion of hyperosmolar solution ($NaHCO_3$)
- ☒ Excessive manipulation of the NB

C) ↓↓ **Blood Outflow**
- ☒ HF
- ☒ Pneumothorax
- ☒ RD
- ☒ CPAP & ↑↑ PEEP
- ☒ Labor process

Clinical Picture

Onset: 50% of cases occur on D1, 75% within the 1st 3 days

1. Blood loss: Pallor, Jaundice, RD, Shock

2. ↑↑ ICT

- Bulging AF
- ↑↑ Head circumference
- High-pitched cry
- Poor activity
- Poor suckling
- Lethargy/Irritability
- Weakness
- Hypotonia
- Muscle twitches
- Seizures

3. Brain stem manifestations

- Apnea
- Temperature instability
- Cranial nerve palsy
- Lost light reflex
- Nystagmus
- Abnormal gaze

4. Intracerebral hemorrhage

- Coma
- Focal neurological deficits: Focal seizures, hemiplegia…

Investigations

Unexplained ↓↓ Hct in a neonate:
- ICH
- Subcapsular hematoma of the liver

A) Laboratory

- CBC:
  - Unexplained anemia
  - Thrombocytopenia
- ↑↑ unconjugated bilirubin (Without evidence of hemolysis)
- ABG: Hypoxia, Hypercapnia, Acidosis

B) Imaging

- **Cranial US** — Method of choice
  - Bed-side method
  - Indications:
    - ➢ Routine: for all preterm neonates < 1.500 gm or GA < 34 ks
    - ➢ F/U: To detect & monitor complications (e.g., hydrocephalus…)
    - ➢ Clinical indications
  - Timing: Within the 1st 7-14 days & at 36 wks PCA
  - Interpretation:

Grades of Subependymal & IVH:
- **Grade I:** Isolated subependymal Hge
- **Grade II:** IVH + No dilatation
- **Grade III:** IVH + Ventricular dilatation
- **Grade IV:** Parenchymal Hge

Grades of Ventricular dilatation:
- **Normal:** < 0.5 cm
- **Mild:** 0.5-1 cm
- **Moderate:** 1-1.5 cm
- **Severe:** > 1.5 cm

- **CT & MRI**
  - Require infant transport which may be risky
  - More sensitive in detection of subdural & intraparenchymal hemorrhage

C) Invasive

- **Lumbar puncture (CSF)**
  - Indications:
    - ➢ ↑↑ ICT
    - ➢ Diagnosis of subarachnoid hemorrhage
    - ➢ Diagnosis of CNS infection
  - Complications: Apnea, bradycardia, circulatory insufficiency

Prevention

- Proper **antenatal** care & careful management of obstetric problems (C/P disproportion)
- Prevention of **prematurity**
- Antenatal **steroid** therapy [Beta- or Dexa-, Betamethasone also ↓↓ PVL]
- Postnatal PG inhibitors (Low-dose **Indomethacin**): ↓↓ incidence of severe IVH
- Avoid **hyperosmolar** solution
- Avoid excessive **manipulation**
- Rx of **maternal** immune diseases associated with neonatal thrombocytopenia (ITP, SLE)??
- Rx of **NATP**??
- **Vitamin K**
  - Antenatal: to the mother receiving phenytoin or phenobarbitone
  - Postnatal: neonatal resuscitation

Monitoring

a. Clinical: Vital signs, Pallor, jaundice, RD
b. Laboratory: Hct%, ABG, electrolytes, blood glucose
c. Imaging: F/U Cranial US (Why??)

Treatment

- Incubator: Isolation, observation
- Vitamin K, FFP, fresh packed RBCs
- Seizures: Anticonvulsants
- Jaundice, DIC,
- Management of complications: Post-hemorrhagic hydrocephalus
  - ➢ Incidence: 10-15%
  - ➢ Diagnosis: Cranial US, CT brain
  - ➢ Types: Communication or obstructive
  - ➢ Treatment
    - F/U: Arrested hydrocephalus
    - Repeated LP: risk of infection
    - Repeated ventricular taps: Risk of infection & puncture porencephaly
    - V/P shunt: Persistent hydrocephalus
    - Ventriculosubgalial shunt: Closed system for CSF drainage
    - Medical (Acetazolamide): Ineffective

Prognosis

- Post-hemorrhagic hydrocephalus
- Parenchymal damage: Cerebral palsy (Spastic), learning difficulties
- Grades I, II: Normal outcome (similar to normal US)
- Poor prognosis in grades III, IV

Brain Injury from Inflammation, Infection & Medications

A) IVH (Severe) & PVL
B) Inflammation: NEC
C) Infections:
  a. In-utero: Congenital infections
  b. Postnatal: Bacterial meningitis
  c. Maternal chrioamnionitis
D) Medications: Postnatal steroids
  a. Within the 1st wk of life: Poor growth, sepsis, bowel perforation
  b. After the 1st wk of life: CP & developmental delay

Mechanism:
- Cytokine release
- SIRS

Spine & Spinal Cord Injury

Etiology

Traction on the spine during difficult labor:

- Cephalic: Delivery of shoulder
- Breech: Delivery of the after-coming head

Pathology

- **Site:** C7 & T1 Vertebrae
- **Pathology:** Edema, hemorrhage, fracture or transection

Clinical Picture

- **Onset:** At birth (Transection) or delayed within the 1st wk (Edema or Hge)
- **Quadriplegia:** Flaccid (Early) then spastic (Later on)…
- **Vital signs:** Respiratory depression, Hypotension, Hypothermia

Treatment

- **Removal of compression**
- **Supportive:** Care of the comatose

Peripheral Nerve Injury

A) Brachial Plexus Injury

Etiology

Traction on the neck during difficult labor:

- Cephalic: Delivery of shoulder
- Breech: Delivery of the after-coming head

Types

	Erb's Paralysis	Klumpke's Paralysis
Root injury	C5, C6	C8, T1
Muscle affected	Deltoid, Biceps, Brachioradialis, Supra- & Infraspinatus-	Intrinsic muscles of the hand
Nature	LMNL	LMNL
Limb Position	Arm: Adduction& Internal rotation Forearm: Pronation Policeman tip	
Reflexes	Absent Moro reflex Intact grasp reflex	Absent grasp reflex
Diaphragmatic	If C4 is injured	
Horner's		If T1 sympathetic fibers are injured
Associations	Diaphragmatic paralysis (C4)	Horner's (T1 sympathetic fibers)
Investigation		
Treatment		
Position (1-2 wks)	90° Adduction, External rotation & Supination	Wrist is splinted (Neutral position) Padding in the fist
Physiotherapy	Gentle range motion exercises (after 2 wks)	
Surgical	Neuroplasty & tendon transfer Not advisable before 3-4 yrs	

B) Phrenic Nerve Injury

Normally, Respiration is entirely diaphragmatic

Etiology
- Usually associated with ipsilateral Erb's palsy
- Usually unilateral

Clinical Picture
- **Irregular respiration & cyanosis**
- **Respiratory movements:** Thoracic (No abdominal movements)

Investigations
- **Fluoroscopy:**
  - Elevation of the diaphragm
  - Seesaw movements (Paradoxical movement)

Treatment
- Position: On the affected side (Why?)
- Respiratory support…+ antibiotics
- Nutrition: IVF then Ryle or oral
- Surgical plication of the diaphragm is rarely indicated (Spontaneous recovery in 1-3 ms)

C) Facial Nerve Injury

Etiology
- Usually unilateral (If bilateral, suspect congenital cause)

Types

	Peripheral	Central
Frequency	More common	Less common
Cause	Pressure on the facial nerve (Hge, edema, forceps)	Facial nuclear agenesis ICH
Nature	LMNL (as Bell's palsy)	UMNL
Part of the face	One side of the face (upper & lower)	Only the lower part
Eye exposure	Yes	No
Treatment		
Eye prophylaxis	Indicated (Methylcellulose)	Not indicated
Surgical	Neuroplasty if nerve fibers are torn	

D) Other Peripheral Nerves

Injury of Sternomastoid Muscle

Etiology

Pathology
- **Hematoma:** Within hours after birth
- **Organization & Fibrosis:** Muscle shortening + Mass (Sternomastoid tumor)

Clinical Picture Mass, Torticollis, Eye problems

Treatment Physiotherapy

Injury of Visceral organs

	Liver (& Spleen)	Adrenal gland
Cause	▪ Pressure on the liver (Breech) ▪ Incorrect cardiac massage	▪ Pressure (Breech) ▪ HIE, Sepsis
Pathology	Subcapsular hematoma	Adrenal hge (90% unilateral, Rt>Lt)
Clinical Picture	▪ Normal: 1-3 days ▪ Blood loss: Pallor, ↑↑ HR, ↑↑ RR ▪ Jaundice ▪ Mass (Rt hypochondrium)	▪ Normal: 1-3 days ▪ Blood loss: Pallor, ↑↑ HR, ↑↑ RR ▪ Jaundice ▪ Mass (Flank) ▪ Asymptomatic: Calcified hematoma
Diagnosis	▪ Early clinical suspicion ▪ Abdominal US	▪ Early clinical suspicion ▪ Abdominal US, CT & MRI ▪ Na, K, Glucose, ABG
Treatment	▪ Packed RBCs ▪ Jaundice ▪ Surgical repair	▪ Packed RBCs ▪ Jaundice ▪ Rx of adrenal insufficiency

Fractures

Fracture Clavicle

Incidence Commonest fracture

Etiology
- Shoulder dystocia
- Breech delivery

Clinical Picture
- No active movement of the affected limb
- Absent Moro reflex
- Crepitus
- Mass (Callus formation)

Treatment
- Immobilization of the affected limb
- Excellent prognosis

Fracture Long Bones

- No active movement of the affected limb
- Absent Moro reflex (UL)
- Immobilization of the affected limb

Fracture Nose

- Fattening of the nose with asymmetric nares

Dislocation & Epiphyseal separation

- No active movement of the affected limb
- Swelling
- Diagnosis: X-rays
- Immobilization of the affected limb ± Surgery

Hormonal Control of mammary gland

A) Puberty
- Estrogen: Development of mammary gland **ducts**
- Progesterone: Development of mammary gland **alveoli**

B) Pregnancy
- Estrogen, Progesterone, Placental lactogen: Development of breast
- Prolactin is secreted (But milk production is inhibited by placental hormones)

C) Childbirth
- Prolactin is no more inhibited → Milk production
- Oxytocin is released in response to suckling → Milk ejection

Reflexes of lactation

A) **Lactating reflexes**

1. **Milk production (Prolactin)**
   - **Stimulus:** Suckling
   - **Effect:** Milk production
2. **Milk ejection (Letdown reflex)**
   - **Stimulus:** Suckling, thinking of the baby or hearing his crying
   - **Effect:** Milk ejection (Oxytocin)

B) **Suckling reflexes**

1. **Rooting**
   - **Stimulus:** Touching of the lips or the corners of the mouth
   - **Effect:** opening of the mouth & head turning towards the side of the stimulus
2. **Sucking**
   - **Stimulus:** Stimulation of the oral cavity (Nipple or finger)
   - **Effect:** Suckling
3. **Swallowing**

Technique of breast feeding

Positioning

1. Infant should be **elevated** to the level of the breast
2. Infant's body should be **turned** completely to face the mother
3. The whole body should be **supported**
4. Infant's **neck** is straight or slightly extended

Attachment

1. **Chin** is touching the breast
2. **Mouth** is widely open
3. **Lower lip** is turned outwards
4. More **areola** is visible above the mouth than below

Effective suckling

1. **Slow deep sucks** ± pauses (Not rapid shallow)
2. **Swallowing** movements
3. Leave the breast **spontaneously**
4. **Relaxed & sleepy** after feeding (Not restless & crying)

Program of breast feeding

Onset **Pattern** **Duration**

Stages of lactation

A) Colostrum

- Timing: 1st 2-3 days after delivery
- Amount: 60 ml/day
- Composition: ↑↑ Protein content (Nutritive & Immunologic value)

Protein content = 8 g/dL

B) **Transitional milk:** Transitional composition between colostrum & mature milk

C) **Mature milk:** is produced within 2-3 weeks

Adequacy of breast feeding

A) Infant

- Weight gain: 750 gm/month (250 gm / 10 days)
- Number of feeds: at least 8 / day
- Urination: 6 wet diapers / day
- Defecation: 4 motions / day
- Sleep after feeding: 2-4 hrs
- Swallowing sounds during feeding

Frequent nursing is not an indication of inadequate lactation

Early weeks of life
Loose stool is passed with each feed (Gastro-colic reflex)

B) Mother

- Breast fullness before feeding
- Let-down reflex (Thinking or hearing cry)

Differences between Human & Cow's Milk

	Item	Breast milk	Cow's milk
	Energy	67 Kcal/100 ml milk	67 Kcal/100 ml milk
	Water	87.5%	87.5%
Proteins	Quantity	1.25 g/dL	3.5 g/dL (↑↑ Renal load)
	Quality	• Whey predominant (4:1) • Easier digestion • Small curd • Immunoglobulins (IgA) • Lactoferrin (?function) • Digestive enzymes (Lipase & amylase) • Growth factors	• Casein predominant (4:1) • Difficult digestion • Bigger curd • No Immunoglobulins (IgA) • No Lactoferrin • Allergenic (Avoid before 1 yr)
Fats	Quantity	3.5 g/dL (More in hind milk)	
	Quality	• Small fat globules • Easier digestion • Volatile FA (Irritant): ↓↓Concentration • Essential FA & cholesterol: ↑↑ [Essential for brain development]	• Large fat globules • Difficult digestion • Volatile FA: ↑↑(GIT Irritation) • Essential FA & cholesterol: ↓↓
CHO	Quantity	7 g/dL	4 g/dL
	Quality	• Lactose is the main sugar • Lactobacillus bifidus promoting factor (Oligosaccharides)	No lactobacillus bifidus…
Minerals	Na	Less Na concentration	More Na
	Ca:P	Less concentration Ratio = 2:1 (Optimum for absorption)	More concentration Ratio = 4:3 (↓↓ absorption)
	Iron	Insufficient (But better absorption)	↓↓ Concentration & absorption
Vit.	A & B	Adequate	Inadequate
	C & D	Inadequate	Inadequate